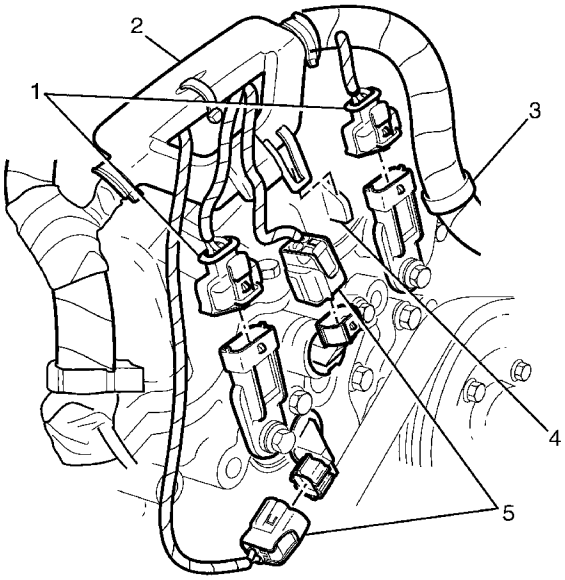
Engine Wiring Harness Assembly Removal

1. Remove the engine covers. Refer to Engine Cover Replacement.



2. Disconnect the right camshaft position sensors electrical connectors (1).

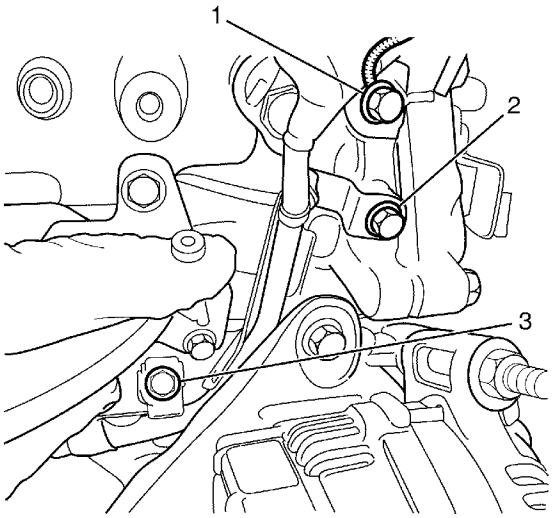
   Important: LE0 and LW2 engines only have an intake camshaft position actuator valve.

3. Disconnect the right bank intake and exhaust camshaft position actuator valve electrical connectors (5).
4. Detach the engine wiring harness to cylinder head retaining lug (3).

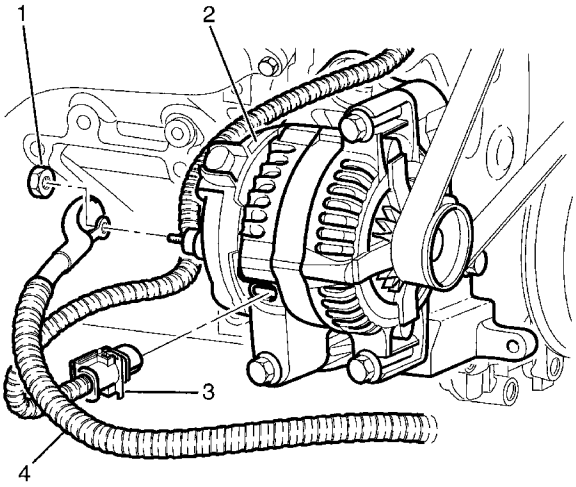
   Important: Use a suitable tool to detach the engine wiring harness bracket (2) from the locating clip lug on the right bank camshaft cover (4) then slide the engine wiring harness bracket (2) upwards to detach from the right bank camshaft cover (4).

5. Detach the engine wiring harness bracket (2) from the right bank camshaft cover (4).

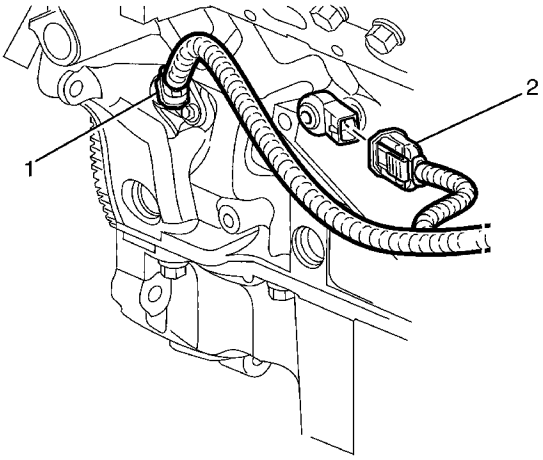
© 2010 General Motors Corporation. All rights reserved.



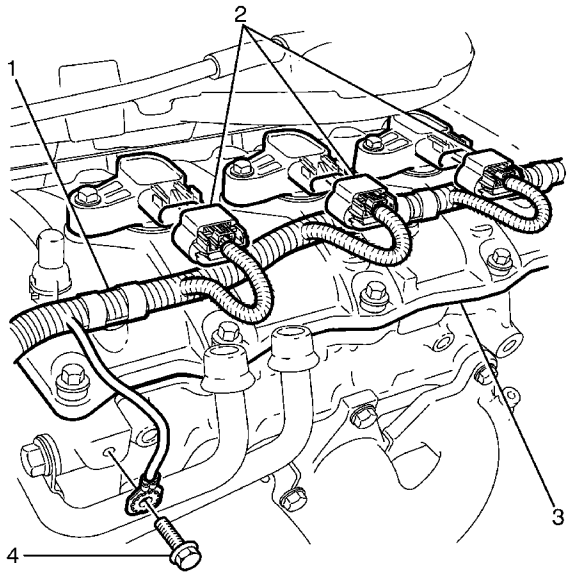
6. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (1).
7. Remove the engine wiring harness bracket to right bank cylinder head retaining bolt (2).
8. Remove the engine wiring harness bracket to cylinder block retaining bolt (3).



9. Remove the battery positive cable to alternator retaining nut (1).
10. Disconnect the battery positive cable (2) from the alternator (3).
11. Disconnect the alternator battery harness connector (4).
12. Remove the alternator and mounting bracket. Refer to Generator Removal.



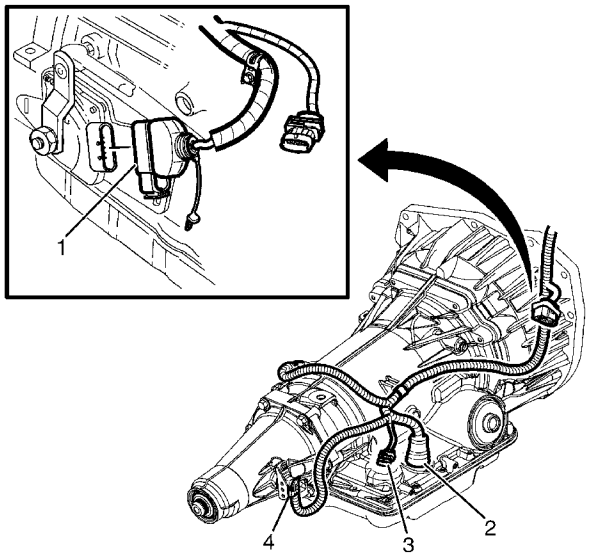
13. Disconnect the right bank knock sensor electrical connector (2).
14. Disconnect the crankshaft position sensor electrical connector (1).



15. Disconnect the right bank ignition coil electrical connectors (2).
16. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (4).

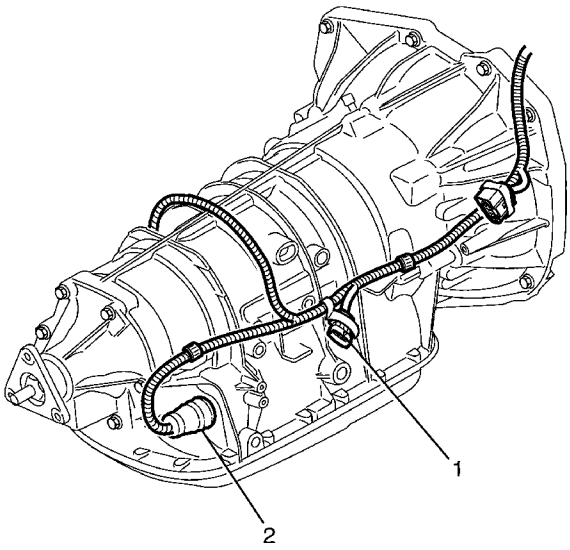
Important: Use a suitable tool to detach the engine wiring harness (1) clips from the right bank camshaft cover (4).

17. Detach the engine wiring harness (1) from the right bank camshaft cover (3).



Important: Steps 19 - 22 refer to the 4L60E 4 speed automatic transmission only.

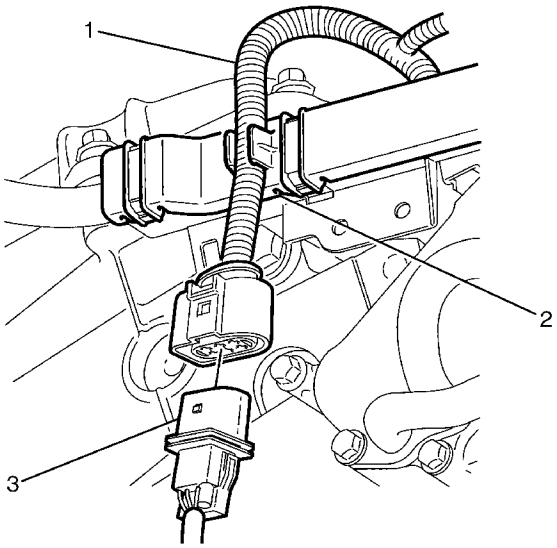
18. Disconnect the right hand Heated Oxygen Sensor 1 electrical connector (2) if still connected after engine removal.
19. Disconnect the main transmission electrical connector (3).
20. Disconnect the vehicle speed sensor electrical connector (4)
21. Disconnect the park/neutral switch electrical connector (1).



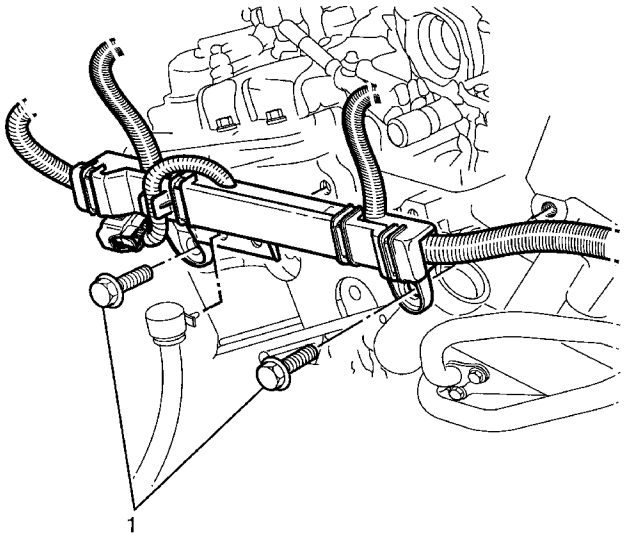
Important: Steps 24 and 25 refer to the 5L40E 5 speed automatic transmission only.

22. Disconnect the right hand Heated Oxygen Sensor 1 electrical connector (1) if still connected after engine removal.

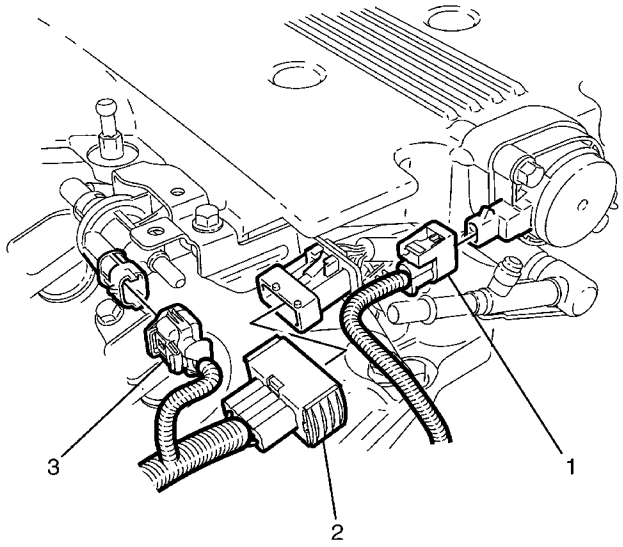
23. Disconnect the main transmission electrical connector (2).



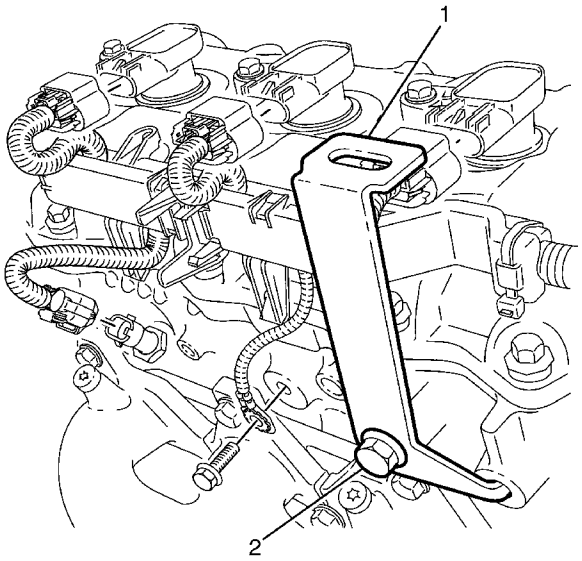
24. Disconnect the left hand Heated Oxygen Sensor 1 electrical connector (3) if still connected after engine removal.
25. Detach the left hand Heated Oxygen Sensor 1 electrical harness (1) from the engine wiring harness bracket (2).



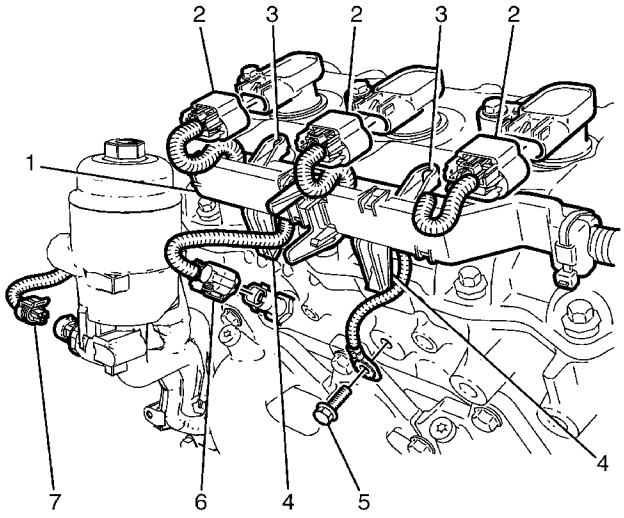
26. Remove the engine wiring harness bracket to cylinder head retaining bolts (1).



27. Disconnect the Intake Manifold Runner Control (IMRC) electrical connector (1).
28. Disconnect the injector harness electrical connector (2).
29. Disconnect the purge solenoid electrical connector (3).



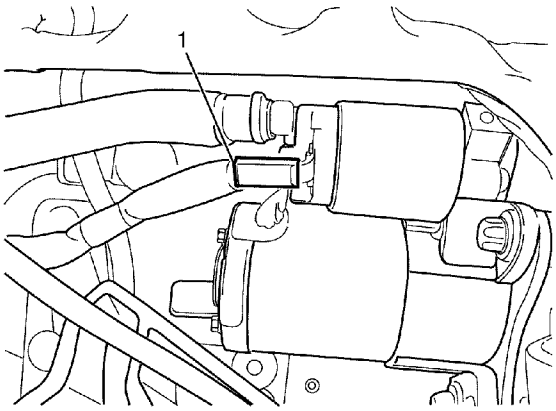
30. Remove the engine cover bracket to cylinder head retaining bolt (2).
31. Remove the engine cover bracket (1).



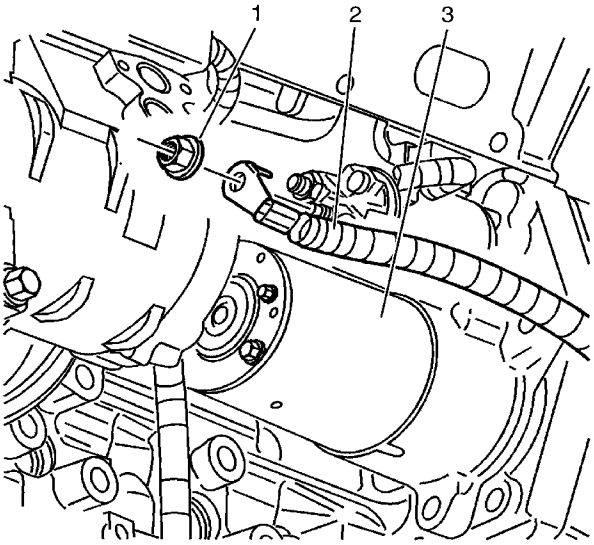
32. Disconnect the left bank ignition coil electrical connectors (2).
33. Remove the engine wiring harness ground to left bank cylinder head retaining bolt (5).
34. Disconnect the coolant temperature sensor electrical connector (6).
35. Disconnect the oil pressure sensor electrical connector (7).

Important: Use a suitable tool to detach the engine wiring harness (1) clips from the right bank camshaft cover clips (4) then lift upwards to detach the engine wiring harness (1) from the right bank camshaft cover lugs (3).

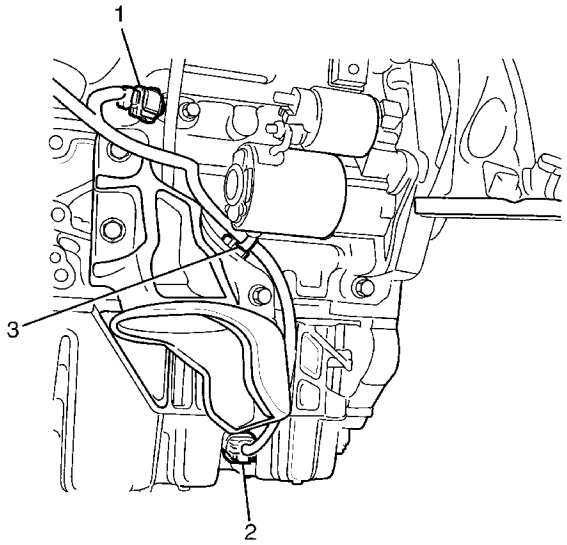
36. Detach the engine wiring harness bracket (1) from the right bank camshaft cover lugs (3) and position aside.



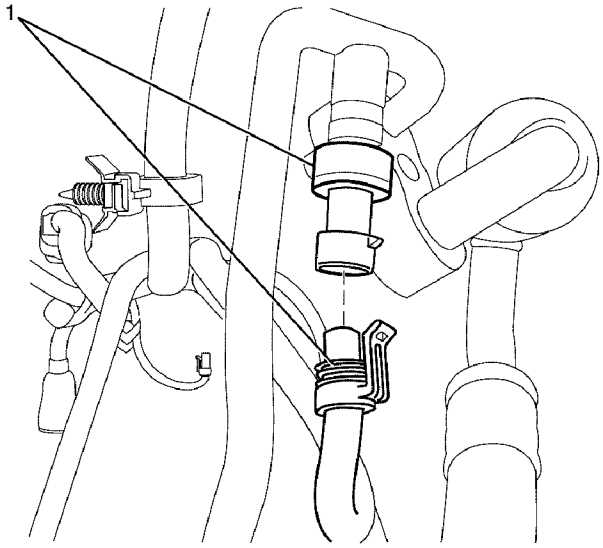
37. Disconnect the starter motor electrical connector (1).



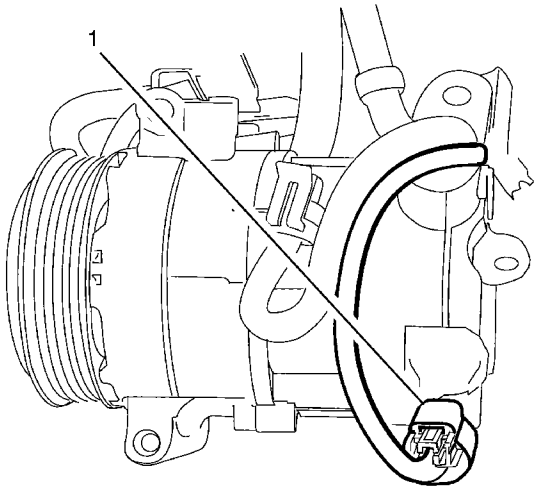
38. Disconnect the battery cable harness (2) from the starter motor (3).
39. Remove the battery cable harness to starter motor retaining nut (1).



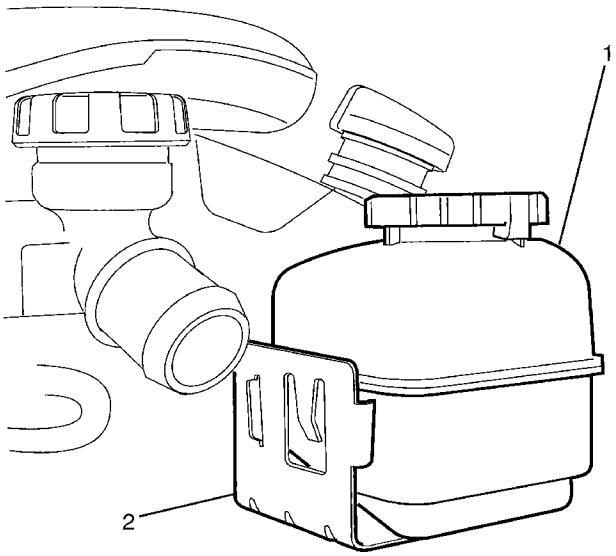
40. Disconnect the left bank knock sensor electrical connector (1).
41. Disconnect the oil level sensor electrical connector (2).
42. Detach the engine wiring harness to cylinder block retaining lug (3).



43. Disconnect the A/C pressure transducer electrical connector (1).



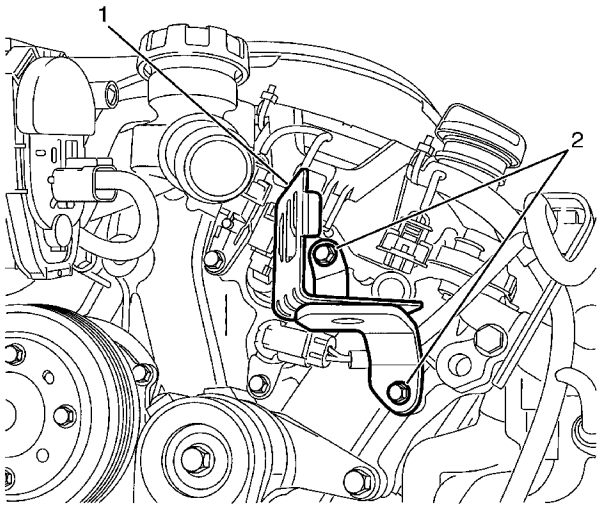
44. Disconnect the A/C compressor electrical connector (1).



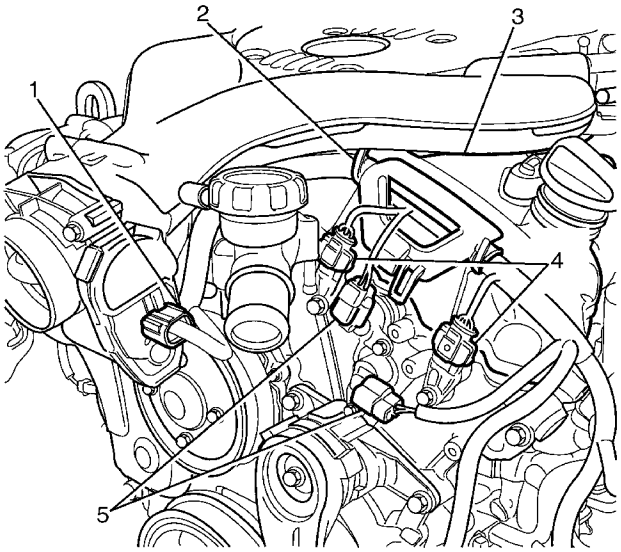
Important: DO NOT disconnect the power steering pipes or drain the power steering fluid.

Important: The locking tang on the power steering reservoir bracket (2) must be released before removing the power steering reservoir (1). Release the locking tang on the power steering reservoir bracket (2) with a suitable tool.

45. Separate power steering fluid reservoir (1) from the power steering fluid reservoir bracket (2).
46. Reposition and secure the power steering fluid reservoir away from the power steering fluid reservoir (1) bracket (2).



47. Remove the power steering fluid reservoir bracket to engine front cover retaining bolts (2).
48. Remove the power steering fluid reservoir bracket (1).



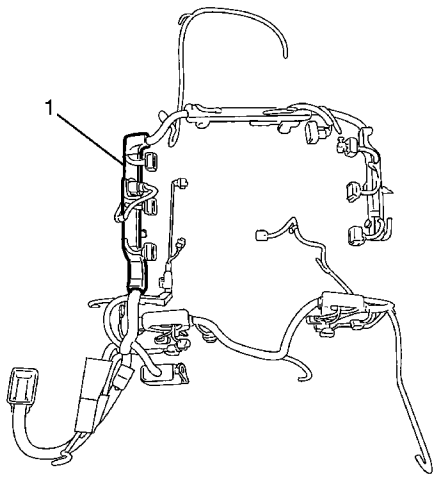
49. Disconnect the left camshaft position sensors electrical connectors (4).

Important: LE0 and LW2 engines only have an intake camshaft position actuator valve.

50. Disconnect the left bank intake and exhaust camshaft position actuator valve electrical connectors (5).
51. Disconnect the throttle position sensor electrical connector (1).

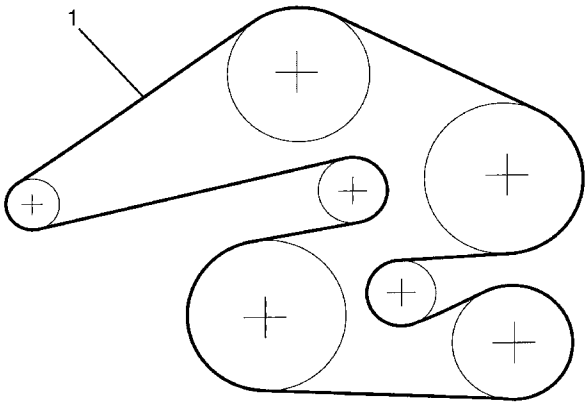
Important: Use a suitable tool to detach the engine wiring harness bracket (2) from the locating clip lug on the left bank camshaft cover (3) then slide the engine wiring harness bracket (2) upwards to detach from the left bank camshaft cover (3).

52. Detach the engine wiring harness bracket (2) from the left bank camshaft cover (3).

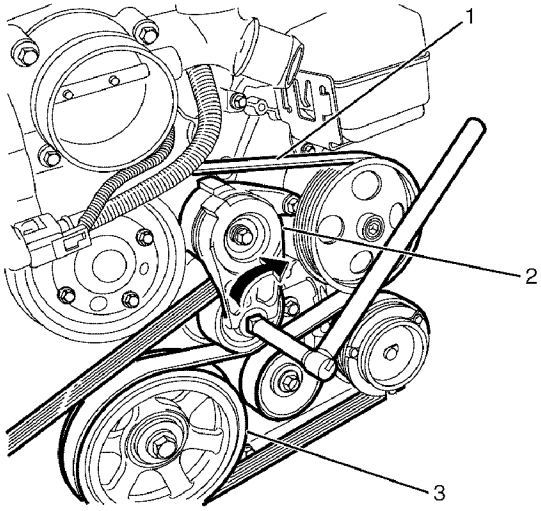


53. Remove the engine wiring harness (1).

Drive Belt Removal



1. Note the routing of the drive belt (1).



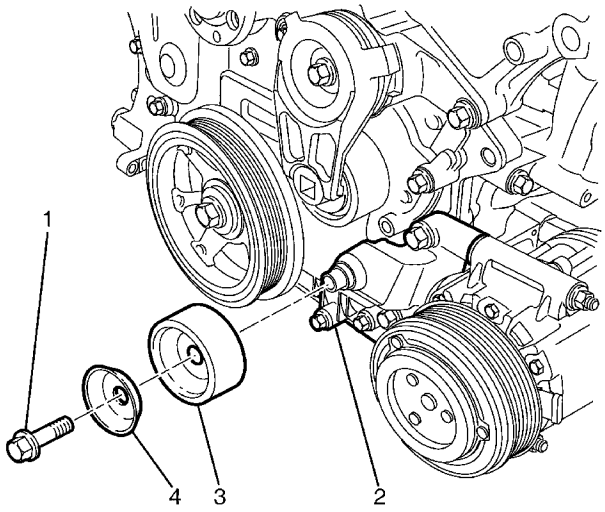
Important: Using a suitable tool rotate the drive belt tensioner (2) clockwise.

2. Rotate the drive belt tensioner (2) clockwise in order to release tension on the drive belt (1).
3. Remove the drive belt (1) from the crankshaft pulley (3).
4. Slowly release the drive belt tensioner (2).

© 2010 General Motors Corporation. All rights reserved.

5. Remove the drive belt (1).

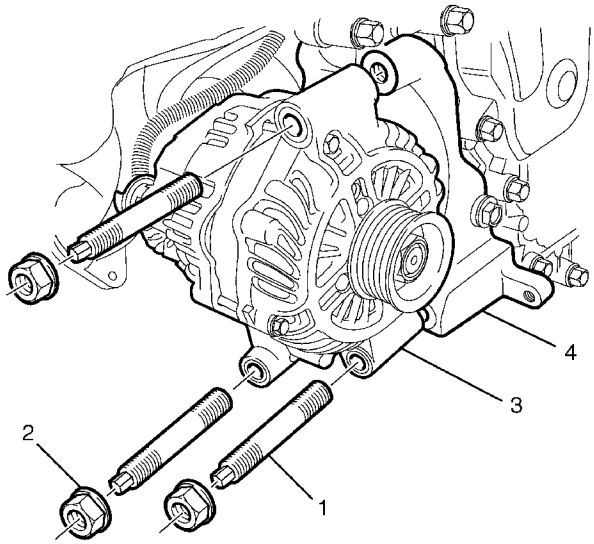
Drive Belt Idler Pulley Removal



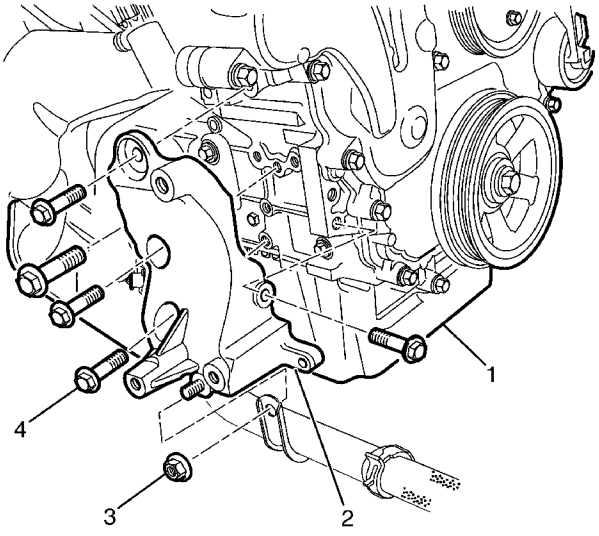
1. Remove the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1).
2. Remove the dished washer (4) and drive belt idler pulley (3) from the accessory drive mounting bracket (2).

© 2010 General Motors Corporation. All rights reserved.

Generator Removal



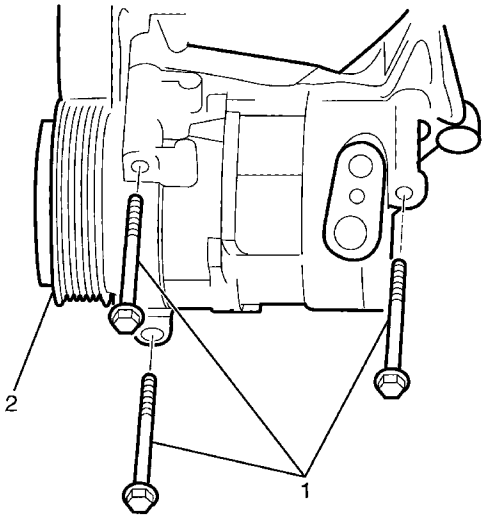
1. Remove the alternator to alternator bracket retaining nuts (2).
2. Remove the alternator to alternator bracket retaining studs (1).
3. Remove the alternator (3) from the alternator bracket (4).



4. Remove the coolant inlet pipe to alternator mounting bracket retaining nut (3)
5. Remove the alternator mounting bracket to cylinder block retaining bolts (4).
6. Remove the alternator mounting bracket (2) from the cylinder block (1).

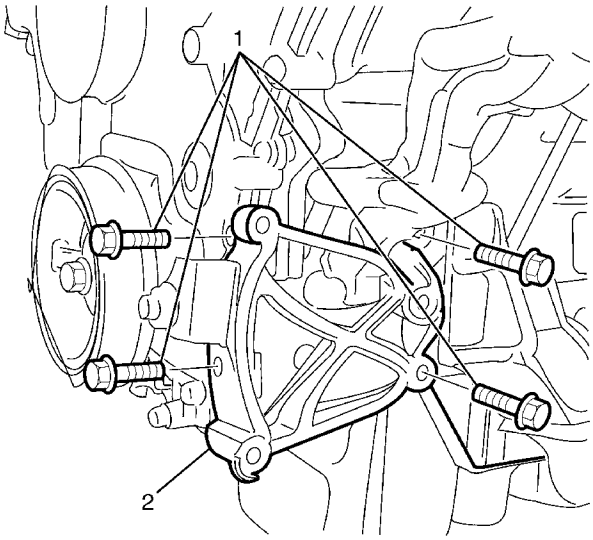
© 2010 General Motors Corporation. All rights reserved.

Air Conditioning (A/C) Compressor Removal



Important: The compressor must be supported before removing the compressor to compressor mounting bracket retaining bolts (1).

1. Remove the compressor to compressor mounting bracket retaining bolts (1).
2. Remove the compressor (2) by sliding forwards and upwards.

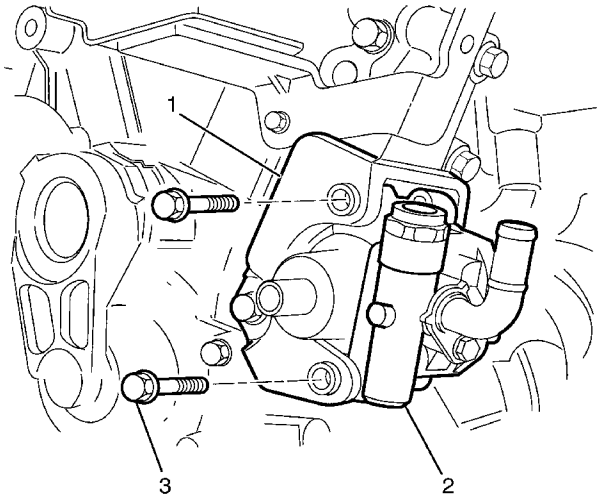


3. Remove the compressor mounting bracket to engine retaining bolts (1).

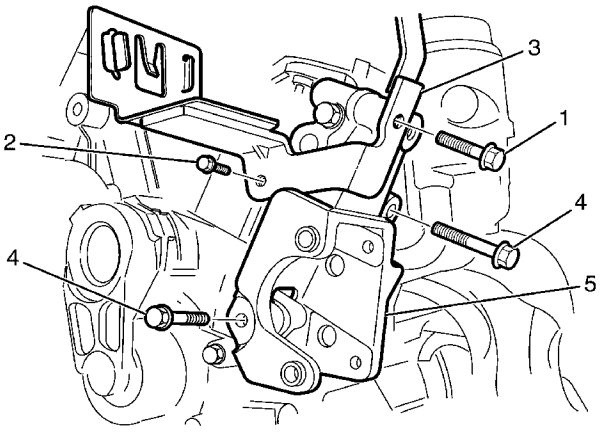
© 2010 General Motors Corporation. All rights reserved.

4. Remove the compressor mounting bracket (2).

Power Steering Pump Removal



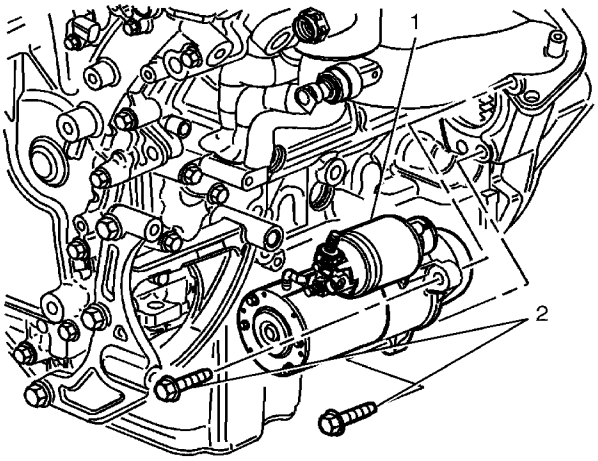
1. Remove the power steering pump to mounting bracket retaining bolts (3).
2. Remove the power steering pump (2) from the power steering pump mounting bracket (1).



3. Remove the power steering reservoir bracket to cylinder head retaining bolt (1).
4. Remove the power steering reservoir bracket to engine front cover retaining bolt (2).
5. Remove the power steering reservoir bracket (3).
6. Remove the power steering pump bracket to cylinder head retaining bolts (4).
7. Remove the power steering pump bracket (5).

© 2010 General Motors Corporation. All rights reserved.

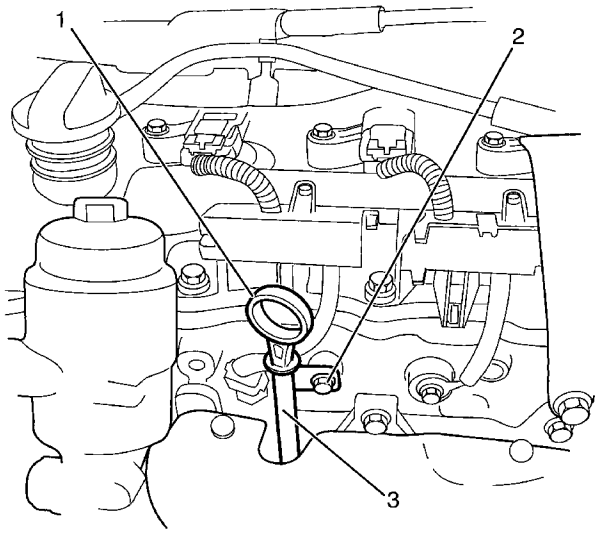
Starter Removal



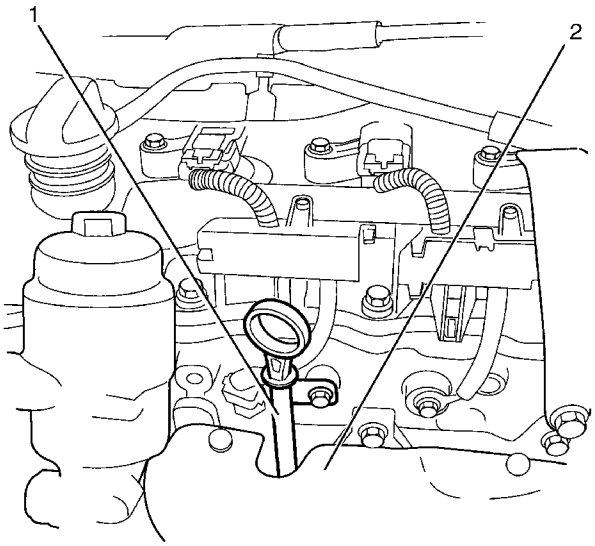
1. Remove the starter motor to cylinder block retaining bolts (2).
2. Remove the starter motor (1).

© 2010 General Motors Corporation. All rights reserved.

Oil Level Indicator and Tube Removal

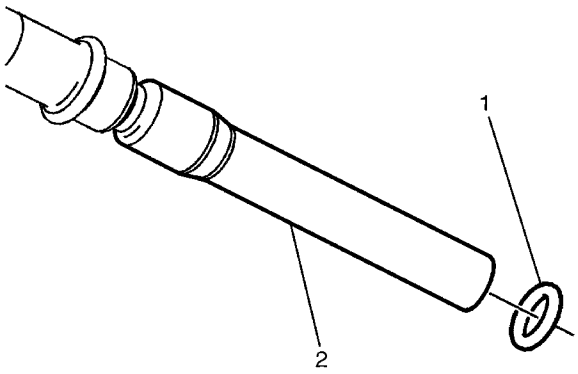


1. Remove the oil level indicator tube bracket to cylinder head retaining bolt (2).
2. Remove the oil level indicator (1) from the oil level indicator tube (3).
3. Remove the knock sensor. Refer to Knock Sensor Replacement - Bank 2.



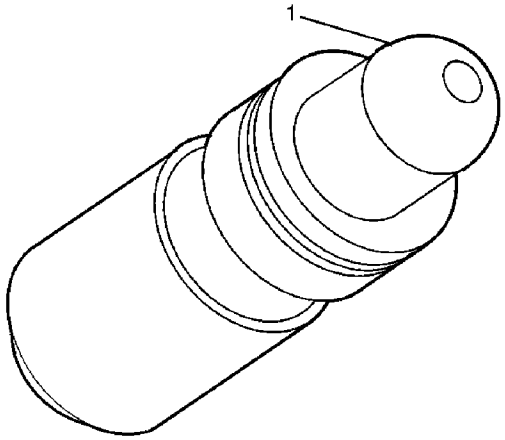
4. Remove the oil level indicator tube (1) up through the exhaust manifold (2).

© 2010 General Motors Corporation. All rights reserved.



5. Remove and discard the O-ring (1) from the oil level indicator tube (2) if damaged.

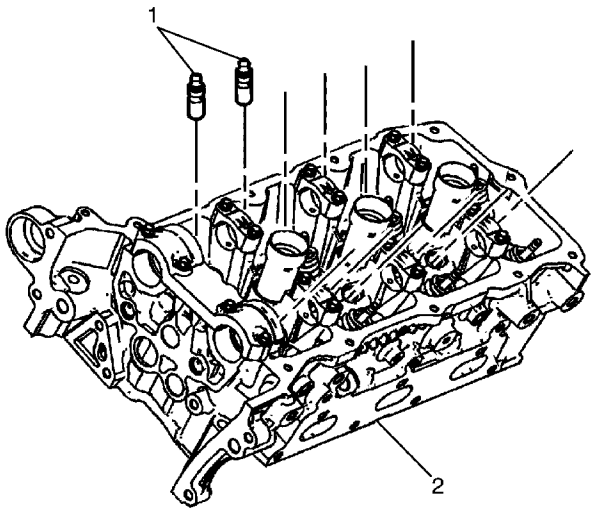
Valve Lifter Installation - Right Side



Important: DO NOT stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

Important: DO NOT allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

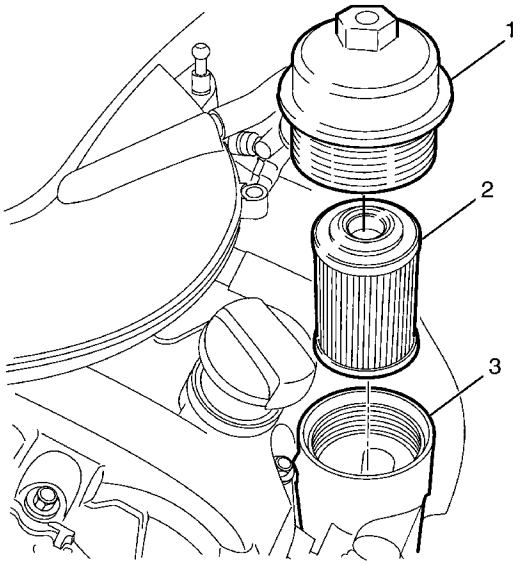
1. Fill the Stationary Hydraulic Lash Adjuster (SHLA) with clean engine oil. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil.



© 2010 General Motors Corporation. All rights reserved.

3. Install the SHLAs (1) in the cylinder head (2).
4. Apply a liberal amount of commercially available camshaft/lifter prelube to the SHLA pivot spheres.

Oil Filter Adapter Removal

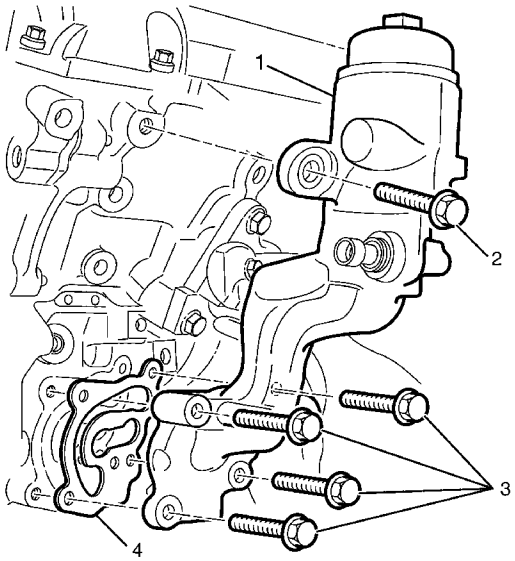


Important: Use a six-point socket to remove the oil filter cap (1).

1. Remove the oil filter adapter cap (1) from the engine oil filter adapter (3).
2. Remove the oil filter cartridge (2).

   Discard the oil filter cartridge (2).

3. Re-install the oil filter cap.

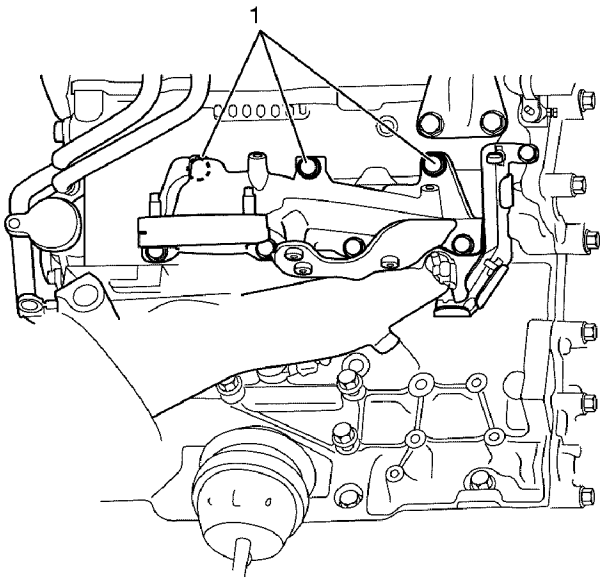


© 2010 General Motors Corporation. All rights reserved.

4. Remove the M8 oil filter adapter to cylinder block retaining bolts (3).
5. Remove the M10 oil filter adapter to cylinder head retaining bolt (2).
6. Remove the oil filter adapter (1).
7. Remove and discard the oil filter adapter gasket (4).

Exhaust Manifold Removal - Right Side

Removal Procedure

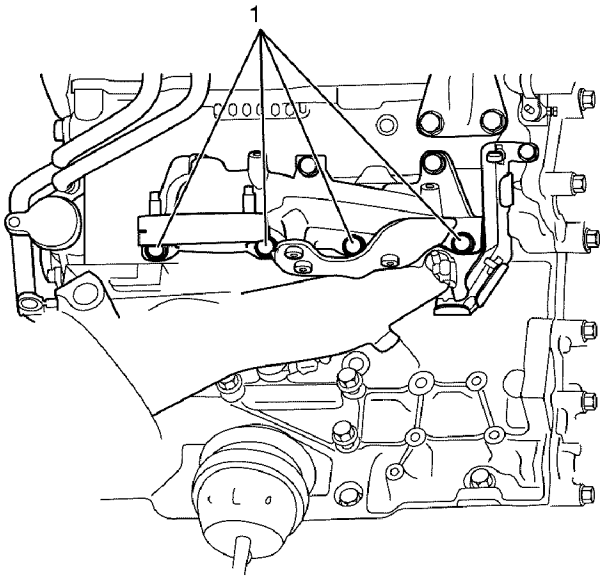


Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

1. Remove the exhaust manifold to cylinder head retaining bolts (1).

   Discard the bolts.

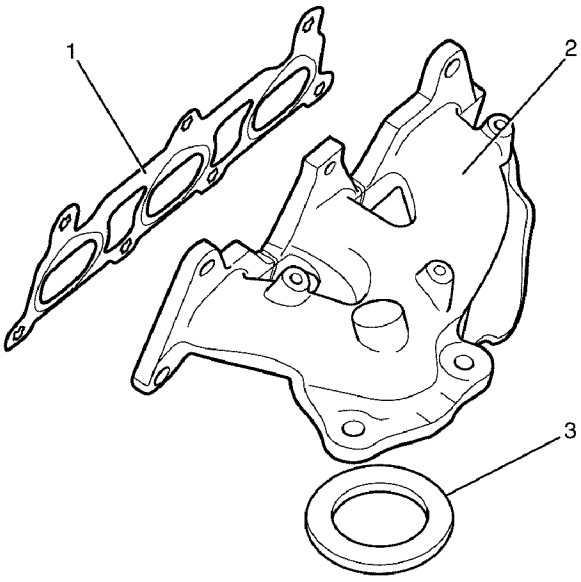
© 2010 General Motors Corporation. All rights reserved.



Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

2. Remove the exhaust manifold to cylinder head retaining bolts (1).

   Discard the bolts.



Note: Make sure that the surrounding wiring harness and electrical connectors are not damaged when removing the exhaust manifold (2).

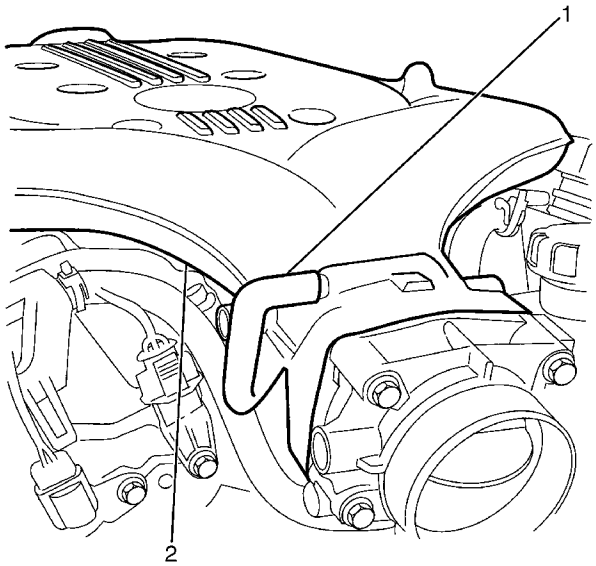
Note: The exhaust manifold gasket (1) and sealing ring (3) are single use parts. They must

be discarded after removal.

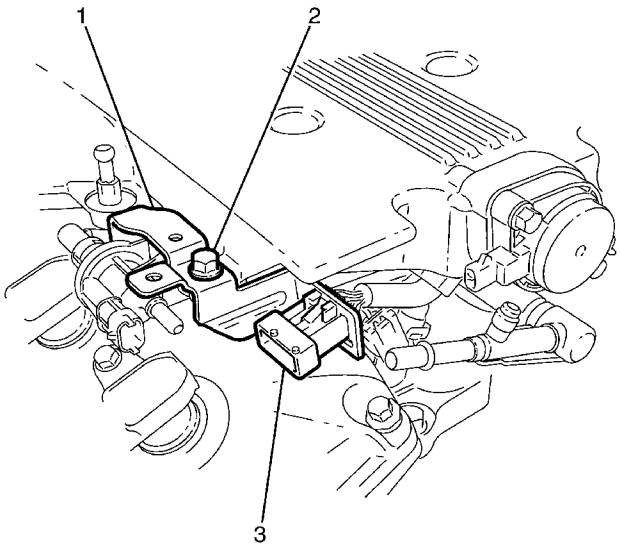
3. Remove the exhaust manifold (2) from the engine assembly.
4. Separate the exhaust manifold (2) from the exhaust manifold gasket (1) and sealing ring (3).
5. Discard the exhaust manifold gasket (1) and sealing ring (3).

Intake Manifold Removal

1. Remove the PCV tube and PCV fresh air tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement .



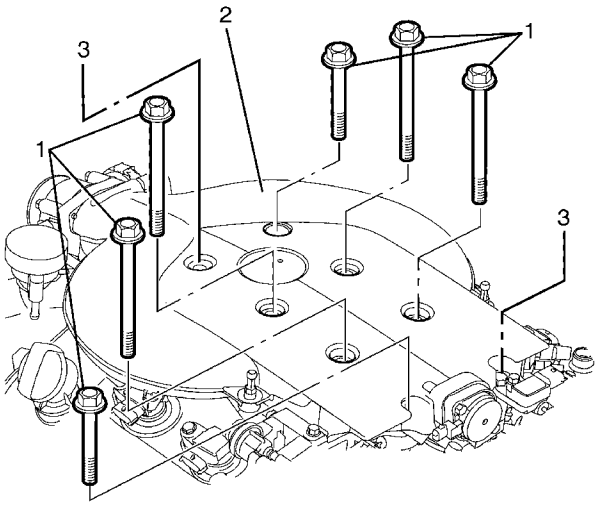
2. Disconnect the EVAP hose (1) from the intake manifold (2).



3. Remove the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2).
4. Detach the fuel injector harness electrical connector (3) from the fuel injector harness electrical connector/EVAP valve mounting bracket (1).

© 2010 General Motors Corporation. All rights reserved.

5. Remove the fuel injector harness electrical connector/EVAP valve mounting bracket (1).



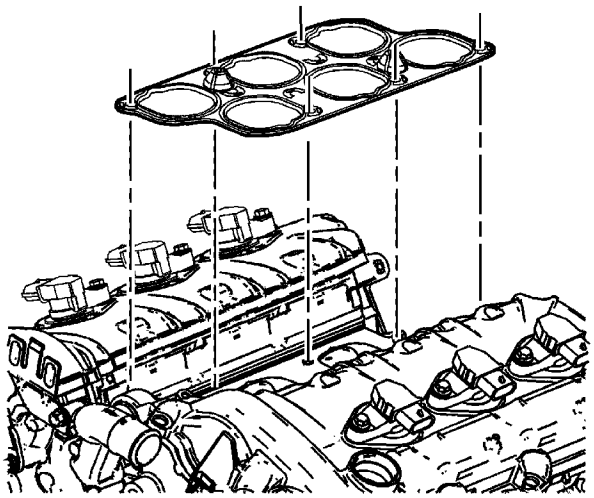
Important:

- DO NOT remove the upper intake manifold to lower intake manifold retaining bolts.
- DO NOT kink or damage the fuel pipe.

6. Remove the intake manifold bolts (1).
7. Remove the intake manifold (2) and the throttle body (3) as an assembly.

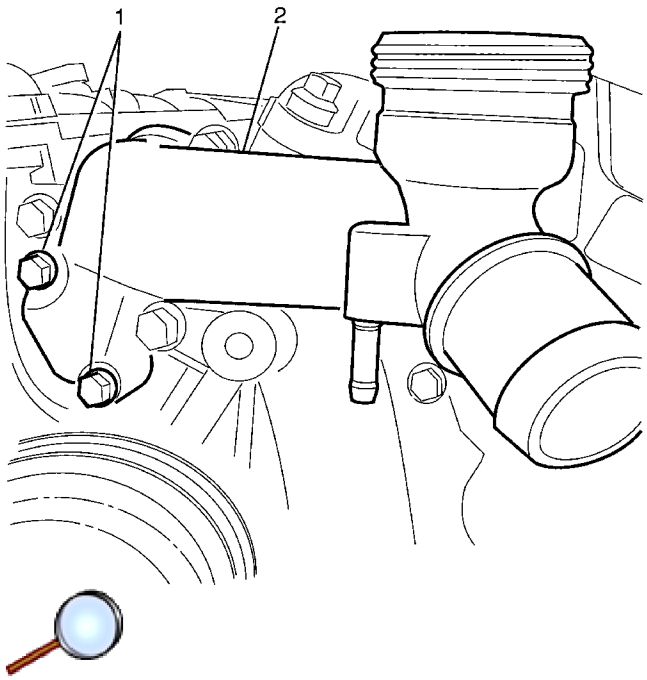
Important: The cylinder heads and engine valley must be plugged with a clean lint free cloth to prevent foreign matter entry into the engine.

8. Plug the cylinder heads and engine valley with a clean lint free cloth.



9. Remove the lower intake manifold gasket.

Water Outlet Removal



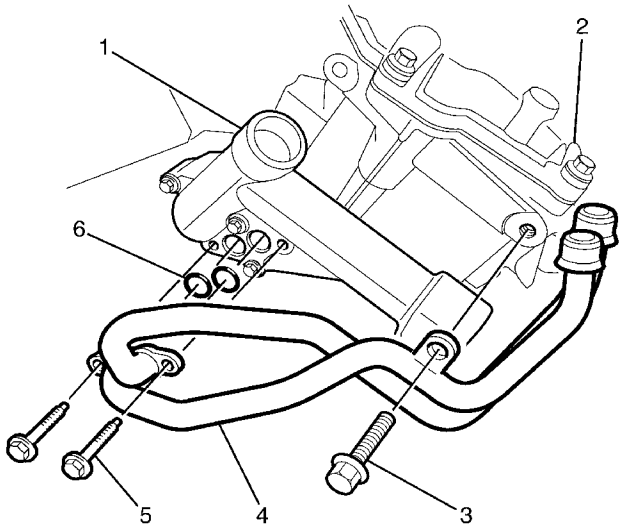
1. Remove the coolant outlet housing to intake manifold retaining bolts (1).

   Important: Use of a soft hammer will aid in the removal of the coolant outlet housing.

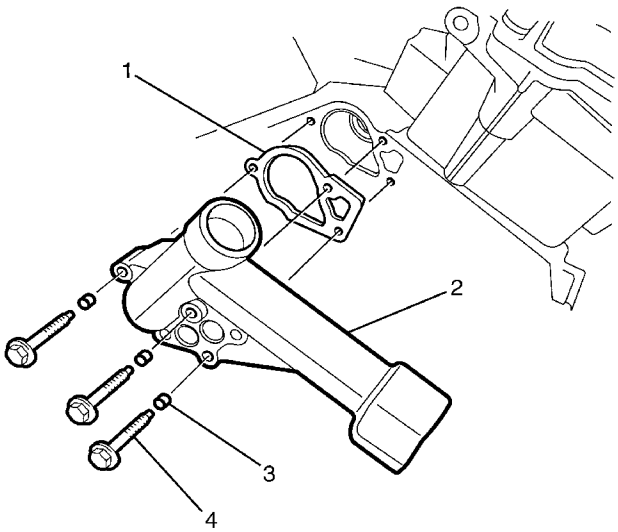
2. Remove the coolant outlet housing (2).
3. Remove the rubber O-ring and seal.

© 2010 General Motors Corporation. All rights reserved.

Engine Coolant Thermostat Housing Removal



1. Remove the heater hose assembly to right bank cylinder head retaining bolt (3).
2. Remove the heater hose assembly to thermostat housing retaining bolts (5).
3. Remove the heater hose assembly (4) from the right bank cylinder head (3) and thermostat housing (1).
4. Remove the O-ring seals (6).



Important: The thermostat housing has one longer bolt which is located in the upper left of

© 2010 General Motors Corporation. All rights reserved.

the housing.

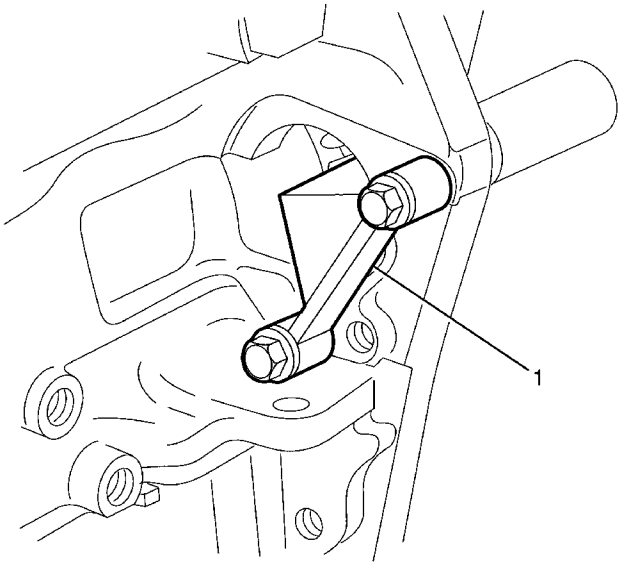
Important: When replacing thermostat housing always renew the block gasket (1).

5. Remove thermostat housing to cylinder block retaining bolts (4) and rubber grommets (3).
6. Remove thermostat housing (2).
7. Remove thermostat housing gasket (1).

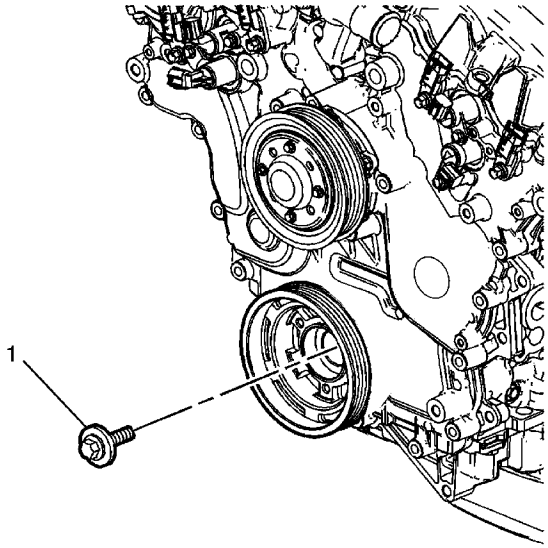
Crankshaft Balancer Removal

Tools Required

- EN 46106 Flywheel Holding Tool
- 303-642 Harmonic Balancer Puller

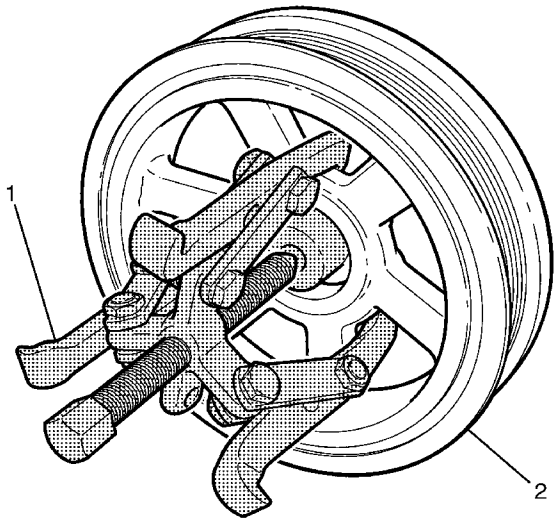


1. Install the EN 46106 (1) through the starter mounting hole.



© 2010 General Motors Corporation. All rights reserved.

2. Remove the crankshaft balancer to crankshaft retaining bolt (1).



3. Install the 303-642 (1).

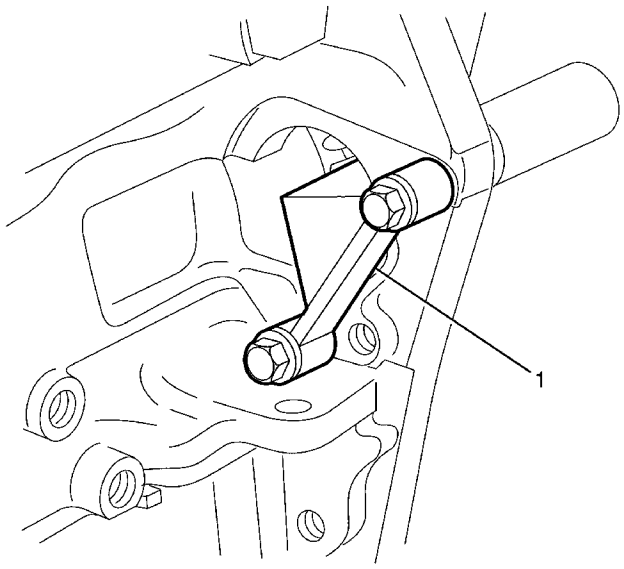
Important: Remove the crankshaft balancer off by tightening the center bolt on the 303-642 (1) until the crankshaft balancer (2) is removed from the crankshaft.

4. Remove the crankshaft balancer (2).
5. Remove the 303-642 (1) from the crankshaft balancer.

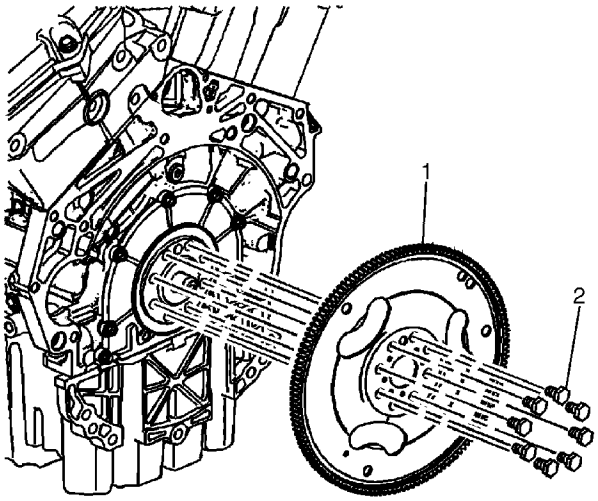
Engine Flywheel Removal

Tools Required

EN 46106 Flywheel Holding Tool



1. Install the EN 46106 (1) through the starter mounting hole.



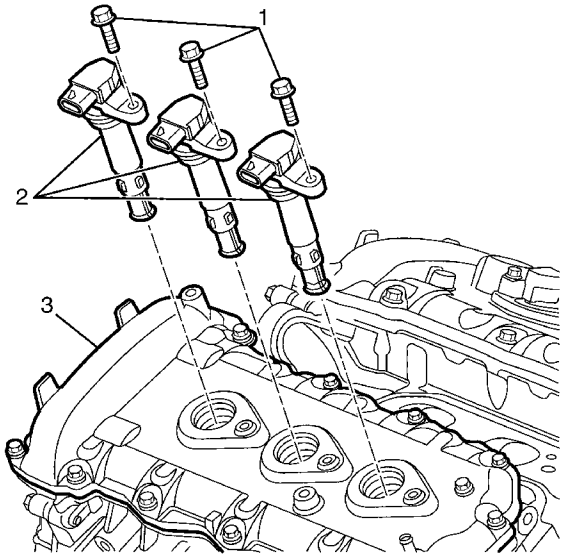
Important: Bolts with micro-encapsulated thread sealant must be discarded after removal.

© 2010 General Motors Corporation. All rights reserved.

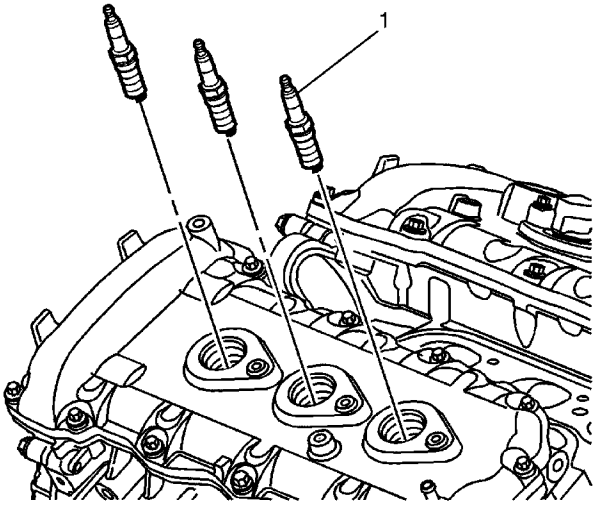
Important: Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

2. Remove the engine flywheel to crankshaft retaining bolts (1).
   - Discard the bolts.
   - Clean the bolt holes.
3. Remove the engine flywheel (2).

Camshaft Cover Removal - Left Side

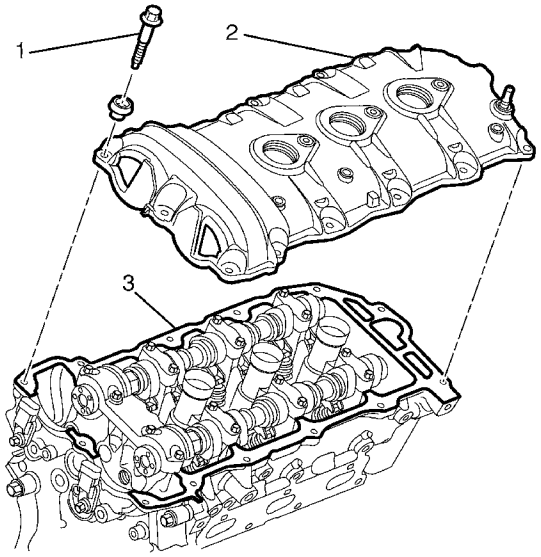


1. Remove the ignition coil to camshaft cover retaining bolts (1).
2. Remove the ignition coils (2) from the camshaft cover (3).



3. Remove the spark plugs (1).

© 2010 General Motors Corporation. All rights reserved.



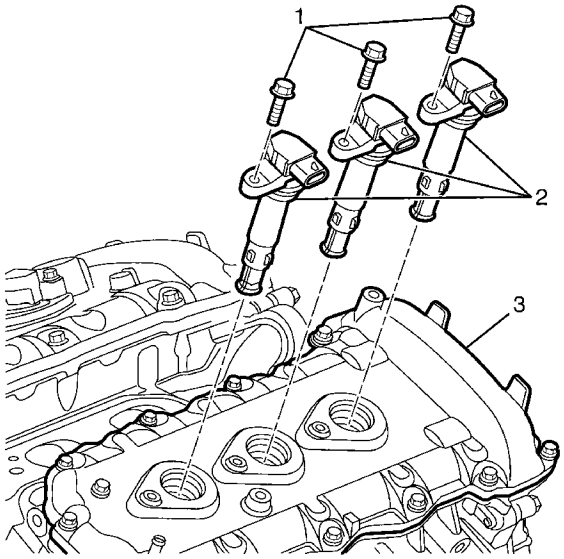
4. Remove the camshaft cover to cylinder head retaining bolts (1).
5. Remove the camshaft cover (2) from the cylinder head (3).

Important: The camshaft cover seal and grommets must be discarded whenever the camshaft cover has been removed from the cylinder head (2).

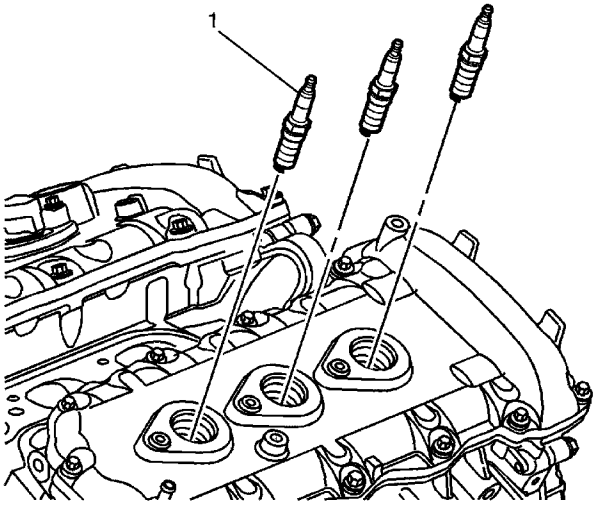
6. Remove the camshaft cover seal and grommets.

   Discard the seal and grommets

Camshaft Cover Removal - Right Side

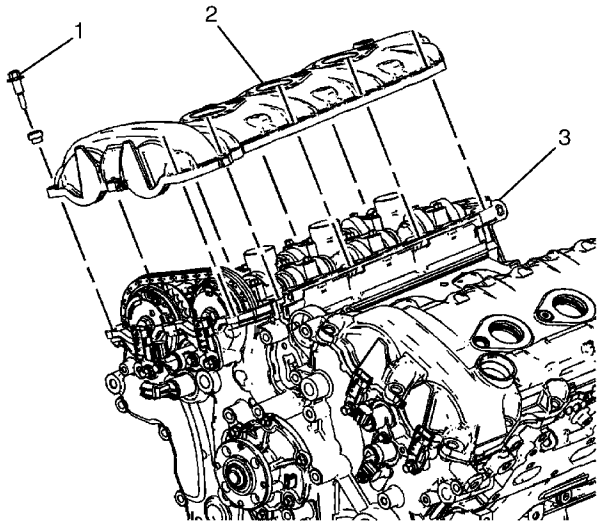


1. Remove the ignition coil to camshaft cover retaining bolts (1).
2. Remove the ignition coils (2) from the camshaft cover (3).



3. Remove the spark plugs (1).

© 2010 General Motors Corporation. All rights reserved.



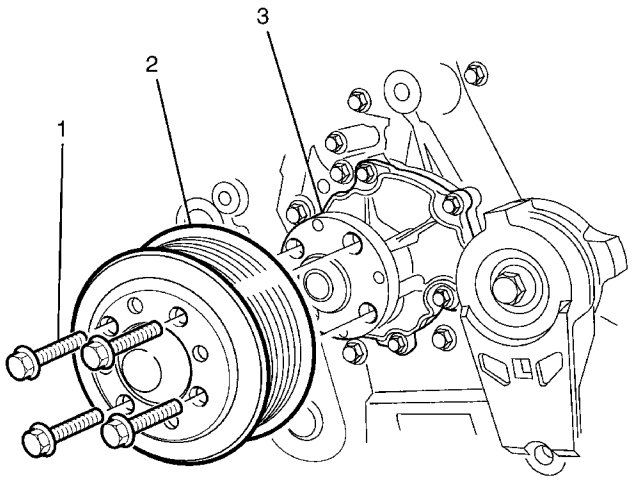
4. Remove the camshaft cover to cylinder head retaining bolts (1).
5. Remove the camshaft cover (2) from the cylinder head (3).

Important: The camshaft cover seal and grommets must be discarded whenever the camshaft cover has been removed from the cylinder head (2).

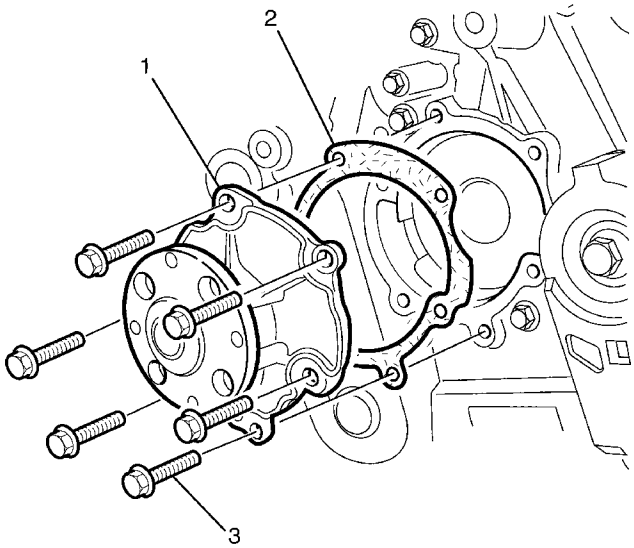
6. Remove the camshaft cover seal and grommets.

   Discard the seal and grommets

Water Pump Removal



1. Remove the water pump pulley to water pump retaining bolts (1).
2. Remove the water pump pulley (2) from the water pump (3).



Important: Use a soft hammer to separate the water pump from the engine cover.

3. Remove the water pump to engine front cover retaining bolts (3).

© 2010 General Motors Corporation. All rights reserved.

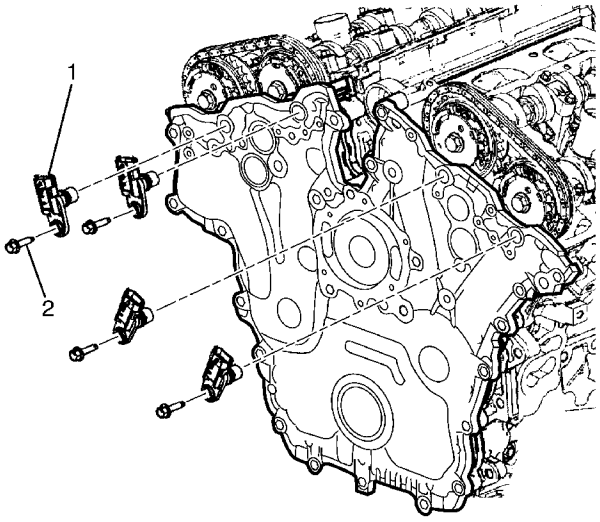
4. Remove the water pump (1).
5. Remove the water pump gasket (2).

   Discard the gasket.

Engine Front Cover Removal

Tools Required

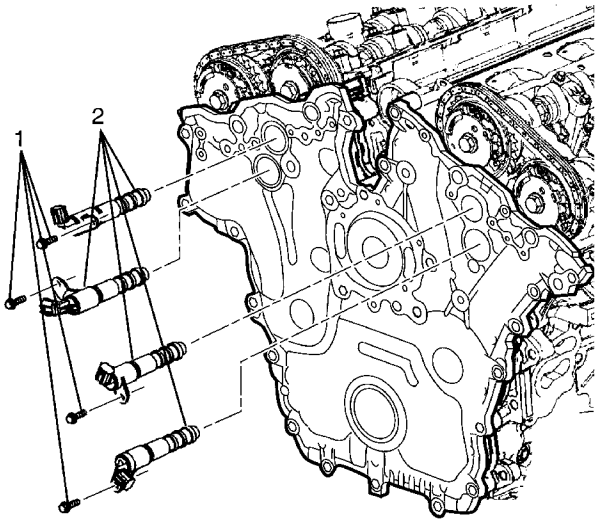
- EN 46105 Camshaft Locking Tools
- EN 46111 Crankshaft Rotation Socket



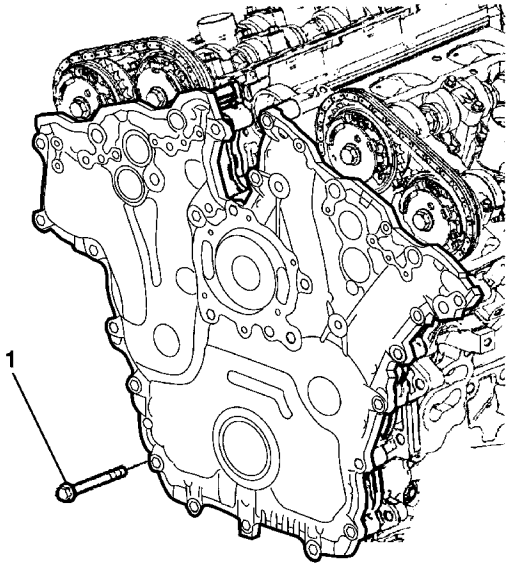
Caution: The camshaft position actuator valves must be removed from the front cover prior to front cover removal or damage to the valves may occur.

1. Remove the camshaft position actuator sensor to engine front cover retaining bolts (2).
2. Remove the camshaft position sensors (1).

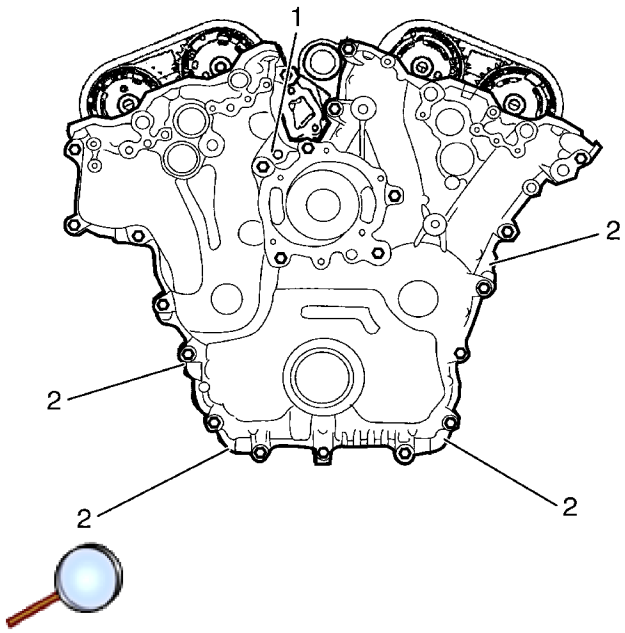
© 2010 General Motors Corporation. All rights reserved.



3. Remove the camshaft position actuator valve to engine front cover retaining bolts (1).
4. Remove the camshaft position actuator valves (2).

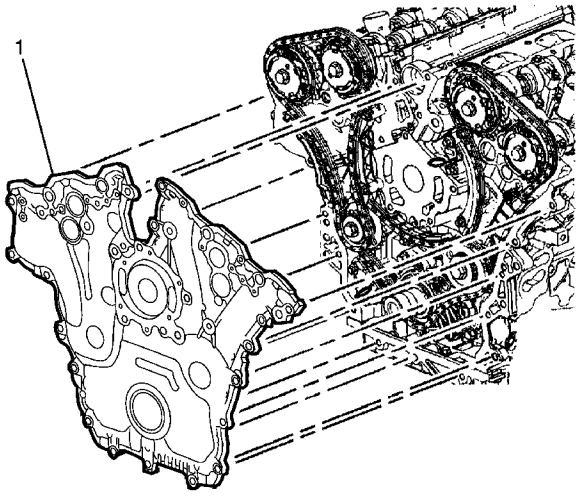


5. Remove the engine front cover to cylinder block retaining bolts (1).

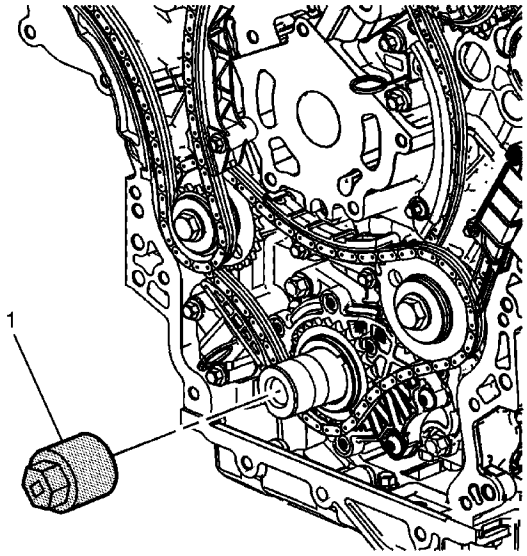


Caution: Do not pry between the engine front cover and the camshaft position sensors or the camshaft position actuators in order to separate the RTV. Use the pry points and a bolt in the jackscrew hole in order to remove the engine front cover. Damage to the camshaft position sensors or the camshaft position actuators may occur if the camshaft position sensors or the camshaft position actuators are used to pry against in order to remove the engine front cover.

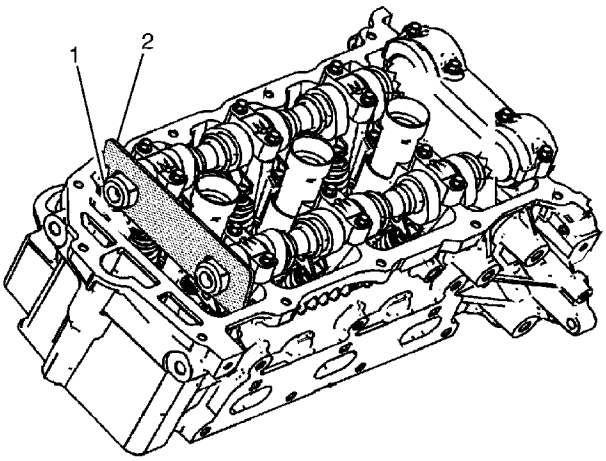
6. Loosely install a 10 x 1.5 mm bolt in the jackscrew hole (1).
7. Using the pry points (2) located at the edge of the front cover and the jackscrew, shear the Room Temperature Vulcanizing (RTV) sealant.



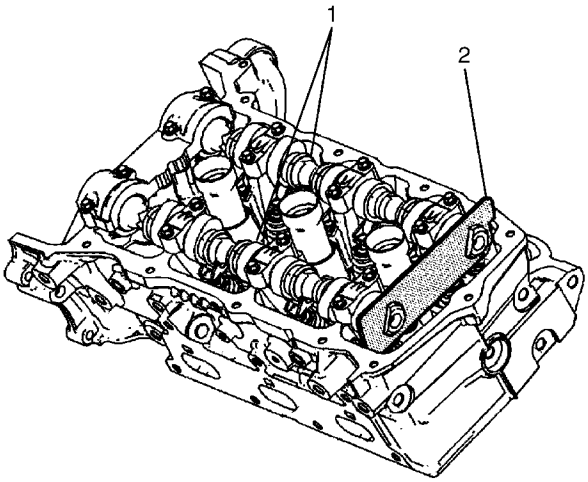
8. Remove the engine front cover (1).



9. Using the EN 46111 (1), rotate the crankshaft until the left cylinder head camshafts align with the EN 46105 and the right cylinder head camshafts align with the EN 46105 .

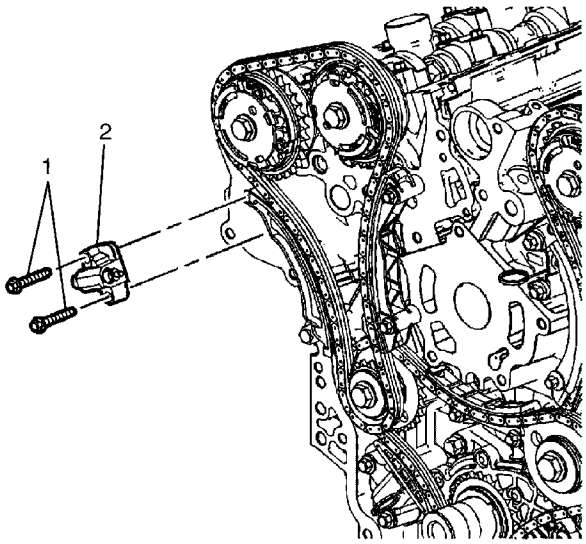


10. Install the EN 46105 (2) onto the rear of the right hand camshafts (1).

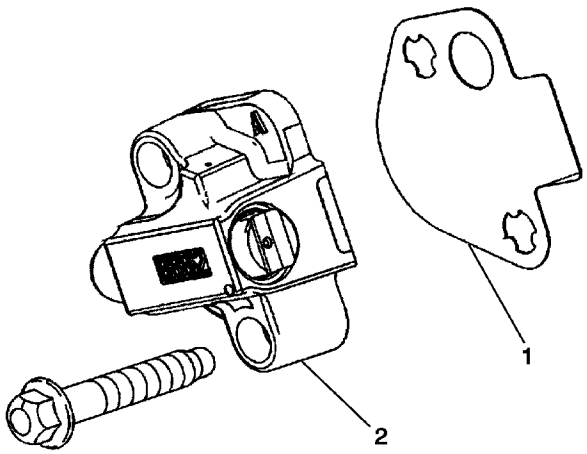


11. Install the EN 46105 (2) onto the rear of the left hand camshafts (1).

Secondary Camshaft Drive Chain Tensioner Removal - Right Side



1. Remove the right secondary camshaft drive chain tensioner to cylinder block retaining bolts (1).
2. Remove the right secondary camshaft drive chain tensioner (2).



Important: The right secondary camshaft drive chain tensioner gasket (2) must be discarded whenever the right secondary camshaft drive chain tensioner (1) has been

© 2010 General Motors Corporation. All rights reserved.

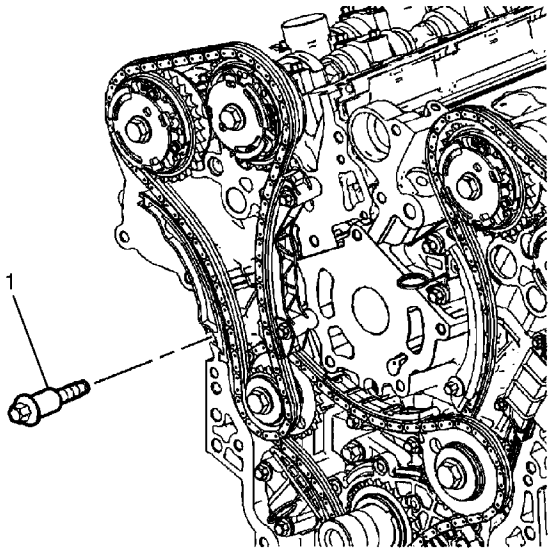
removed from the cylinder block.

3. Remove the right secondary camshaft drive chain tensioner gasket (1) from the right secondary camshaft drive chain tensioner (2).

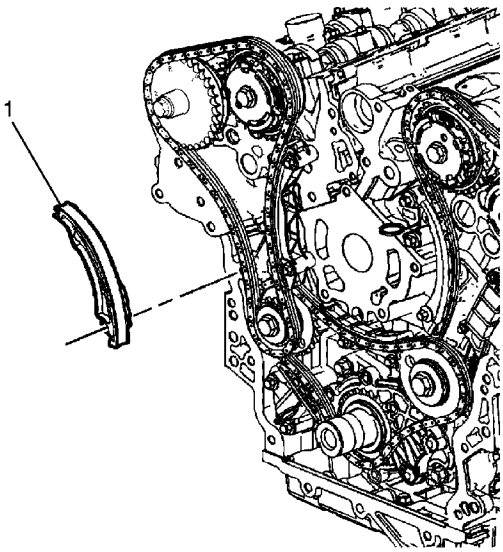
   Discard the gasket.

4. Inspect the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head for burrs or any defects that may degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.

Secondary Camshaft Drive Chain Shoe Removal - Right Side



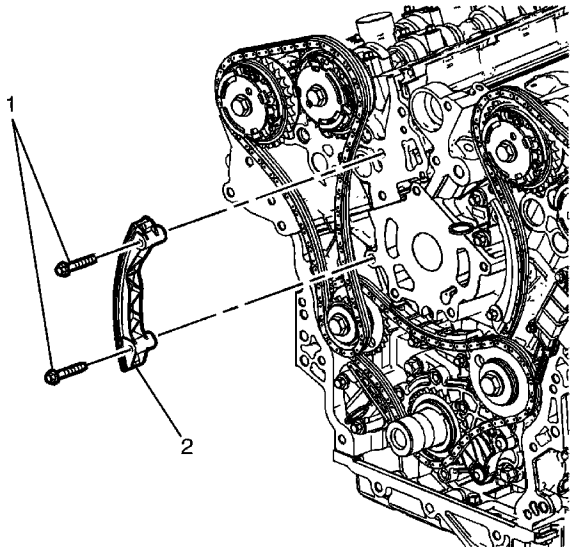
1. Remove the right secondary camshaft drive chain shoe to cylinder block retaining bolt (1).



2. Remove the right secondary camshaft drive chain shoe (1).

© 2010 General Motors Corporation. All rights reserved.

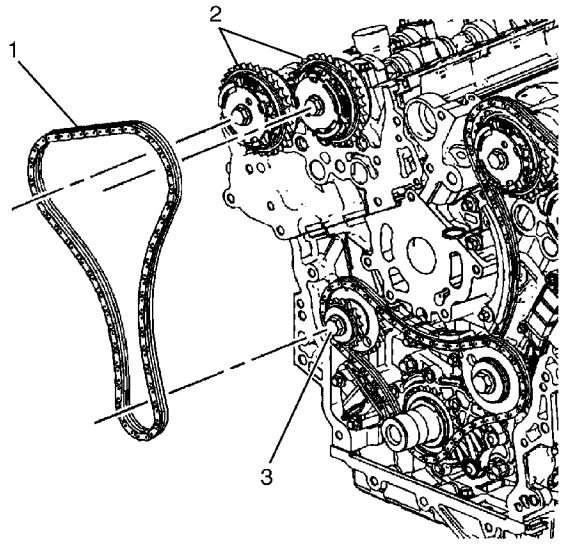
Secondary Camshaft Drive Chain Guide Removal - Right Side



1. Remove the right secondary camshaft drive chain guide to cylinder block retaining bolts (1).
2. Remove the right secondary camshaft drive chain guide (2).

© 2010 General Motors Corporation. All rights reserved.

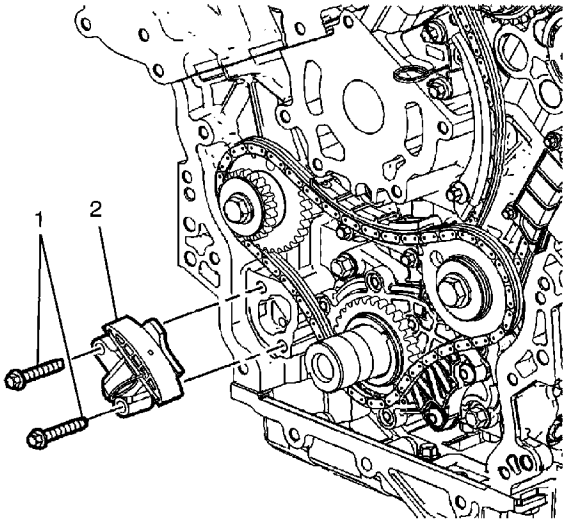
Secondary Camshaft Drive Chain Removal - Right Side



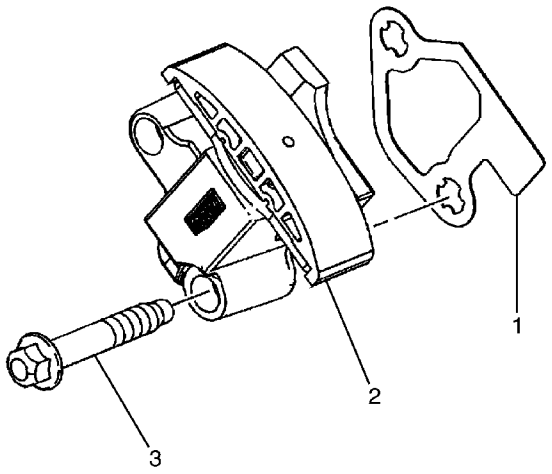
Remove the right secondary camshaft drive chain (1) from the right camshaft position actuators (2) and the right camshaft intermediate drive chain idler sprocket (3).

© 2010 General Motors Corporation. All rights reserved.

Primary Camshaft Intermediate Drive Chain Tensioner Removal



1. Remove the primary camshaft drive chain tensioner to cylinder block retaining bolts (1).
2. Remove the primary camshaft drive chain tensioner (2).



3. Remove the primary camshaft drive chain tensioner bolts (3) from the primary camshaft drive chain tensioner (2) and gasket (1).

Important: The primary camshaft drive chain tensioner gasket (1) must be discarded

© 2010 General Motors Corporation. All rights reserved.

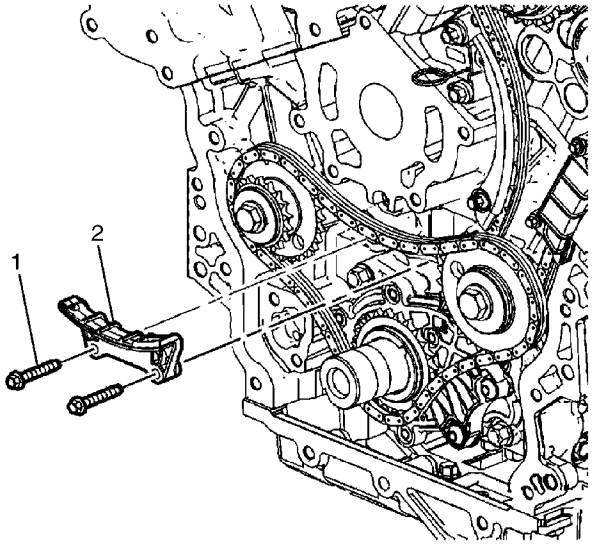
whenever the primary camshaft drive chain tensioner (2) has been removed from the cylinder block.

4. Remove the primary camshaft drive chain tensioner gasket (1) from the primary camshaft drive chain tensioner (2).

   Discard the gasket.

5. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.

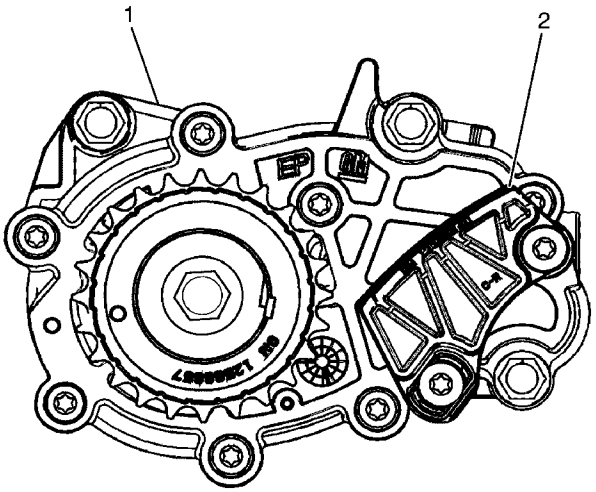
Primary Timing Chain Guide Removal - Upper



1. Remove the primary camshaft drive chain upper guide to cylinder block retaining bolts (1).
2. Remove the primary camshaft drive chain upper guide (2).

© 2010 General Motors Corporation. All rights reserved.

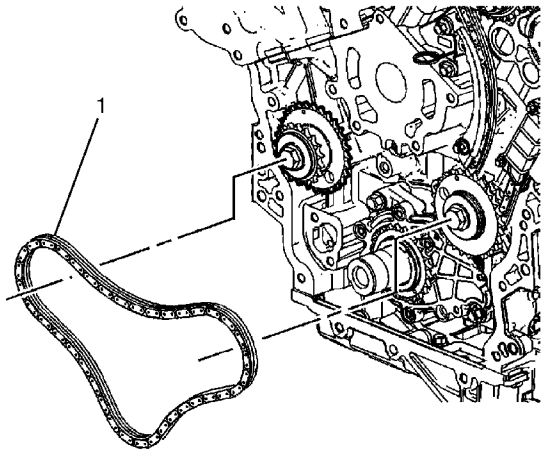
Primary Timing Chain Guide Removal - Lower



DO NOT remove the primary camshaft drive chain lower guide (2). The primary camshaft drive chain lower guide (2) is not serviceable separately. If the primary camshaft drive chain lower guide (2) must be replaced, the oil pump (1) must be replaced.

© 2010 General Motors Corporation. All rights reserved.

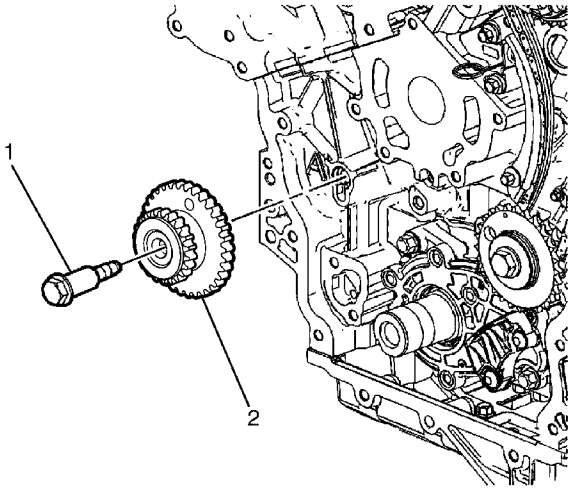
Primary Camshaft Intermediate Drive Chain Removal



Remove the primary camshaft drive chain (1).

© 2010 General Motors Corporation. All rights reserved.

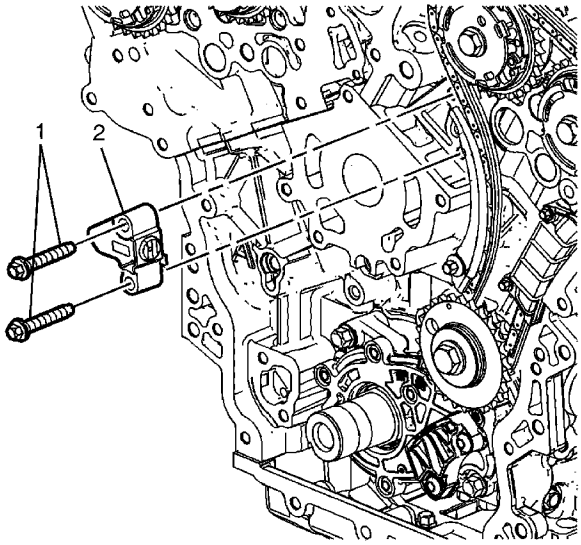
Camshaft Intermediate Drive Chain Idler Removal - Right Side



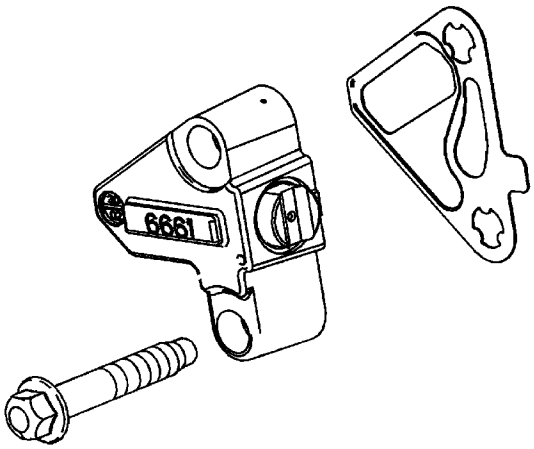
1. Remove the right camshaft intermediate drive chain idler bolt (1).
2. Remove the right camshaft intermediate drive chain idler (2).

© 2010 General Motors Corporation. All rights reserved.

Secondary Camshaft Drive Chain Tensioner Removal - Left Side



1. Remove the left secondary camshaft drive chain tensioner to cylinder block retaining bolts (1).
2. Remove the left secondary camshaft drive chain tensioner (2).



Important: The left secondary camshaft drive chain tensioner gasket must be discarded whenever the left secondary camshaft drive chain tensioner has been removed from the

© 2010 General Motors Corporation. All rights reserved.

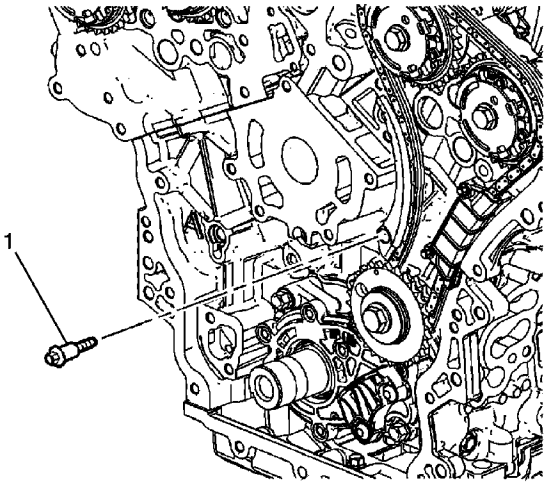
cylinder block.

3. Remove left secondary camshaft drive chain tensioner gasket from the left secondary camshaft drive chain tensioner.

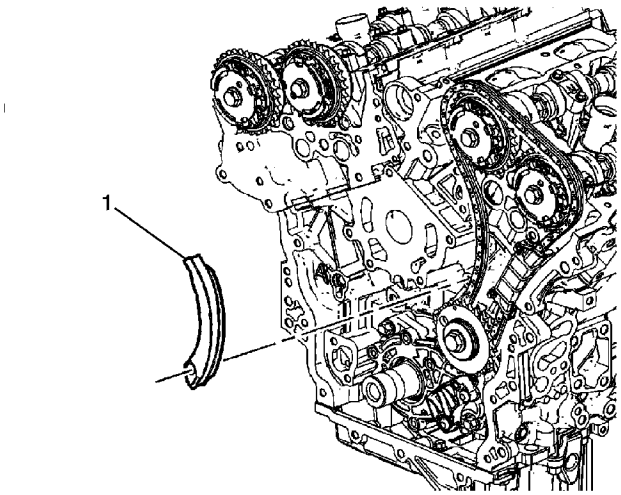
   Discard the gasket.

4. Inspect the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head for burrs or any defects that may degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.

Secondary Camshaft Drive Chain Shoe Removal - Left Side



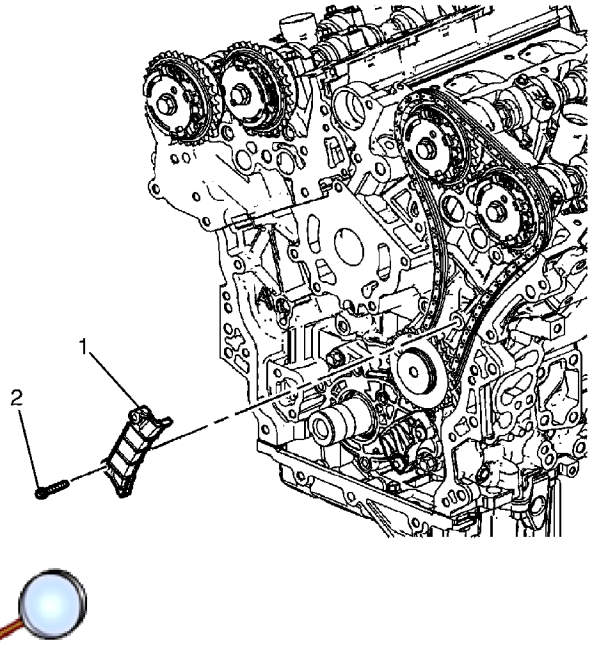
1. Remove the left secondary camshaft drive chain shoe to cylinder block retaining bolt (1).



2. Remove the left secondary camshaft drive chain shoe (1).

© 2010 General Motors Corporation. All rights reserved.

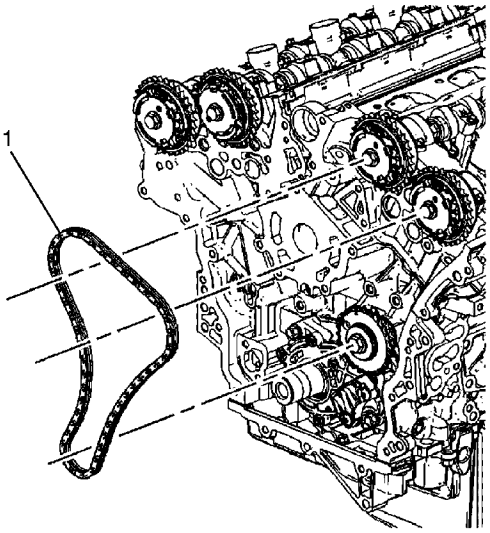
Secondary Camshaft Drive Chain Guide Removal - Left Side



1. Remove the left secondary camshaft drive chain guide to cylinder block retaining bolts (2).
2. Remove the left secondary camshaft drive chain guide (1).

© 2010 General Motors Corporation. All rights reserved.

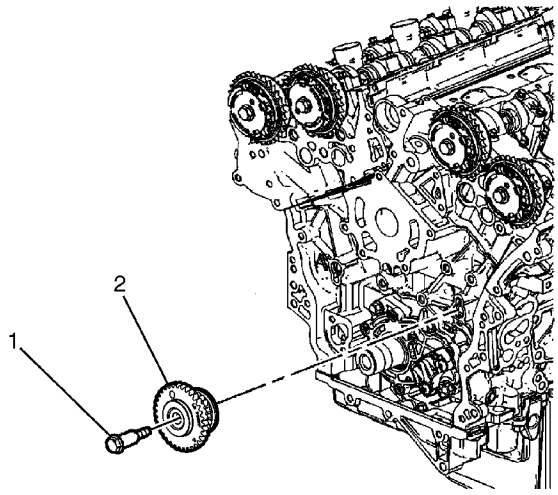
Secondary Camshaft Drive Chain Removal - Left Side



Remove the left secondary camshaft drive chain (1).

© 2010 General Motors Corporation. All rights reserved.

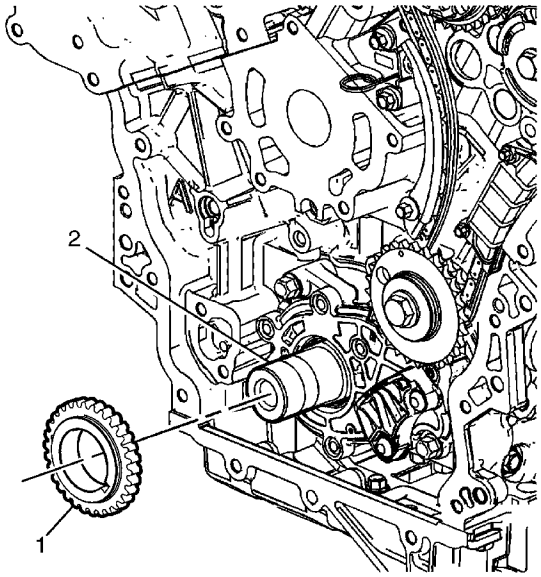
Camshaft Intermediate Drive Chain Idler Removal - Left Side



1. Remove the left camshaft intermediate drive chain idler to cylinder block retaining bolt (1).
2. Remove the left camshaft intermediate drive chain idler (2).

© 2010 General Motors Corporation. All rights reserved.

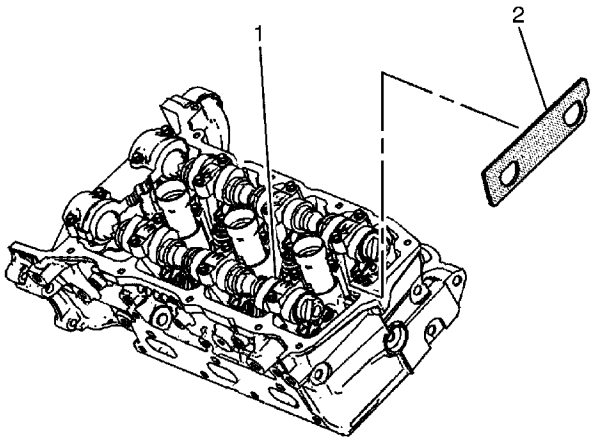
Crankshaft Sprocket Removal



Remove the crankshaft sprocket (1) from the nose of the crankshaft (2).

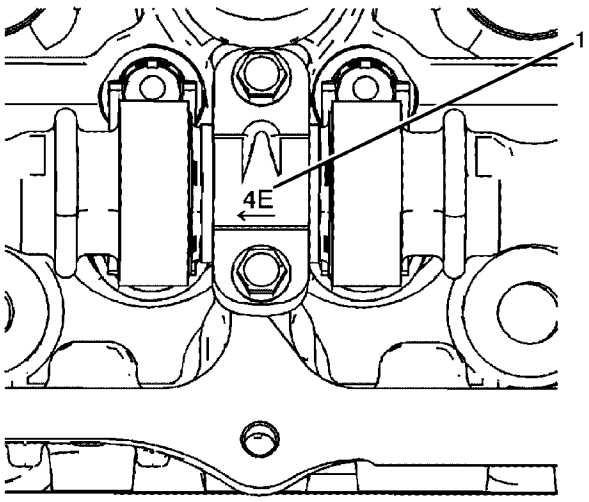
© 2010 General Motors Corporation. All rights reserved.

Camshaft Removal - Left Side



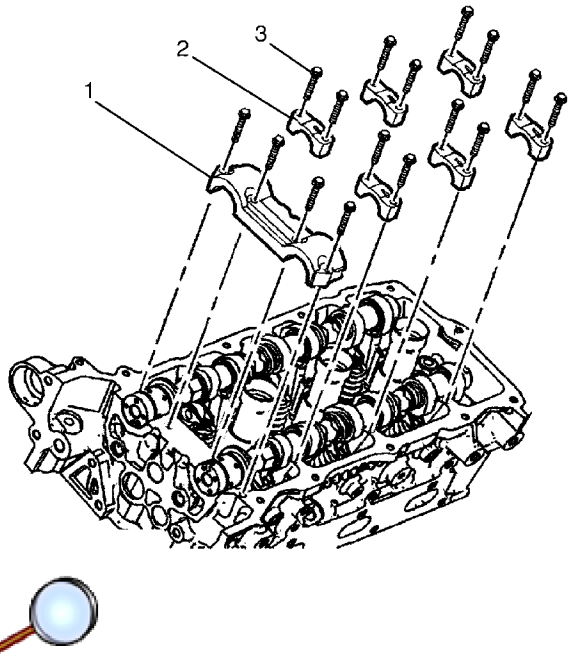
Important: EN 46105 (2) was installed to the camshafts (1) as part of the left bank cylinder head camshaft position actuator removal procedure.

1. Remove the EN 46105 (2) from the left bank camshafts (1).
2. Position the camshaft lobes in a neutral position.

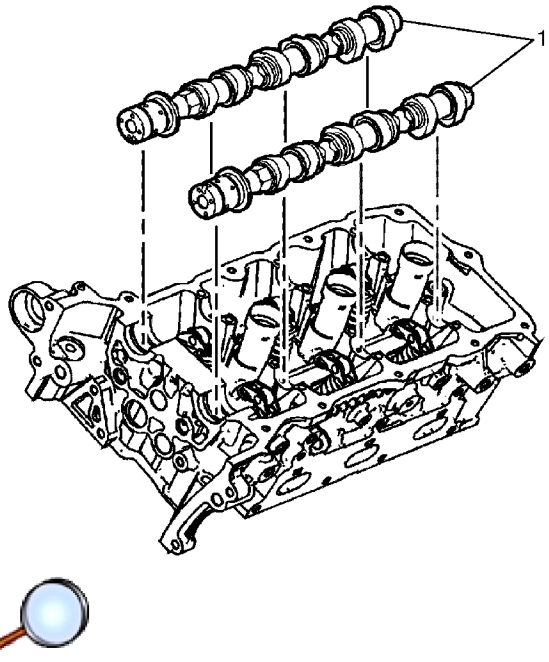


© 2010 General Motors Corporation. All rights reserved.

3. Observe the markings (1) on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the cylinder block.

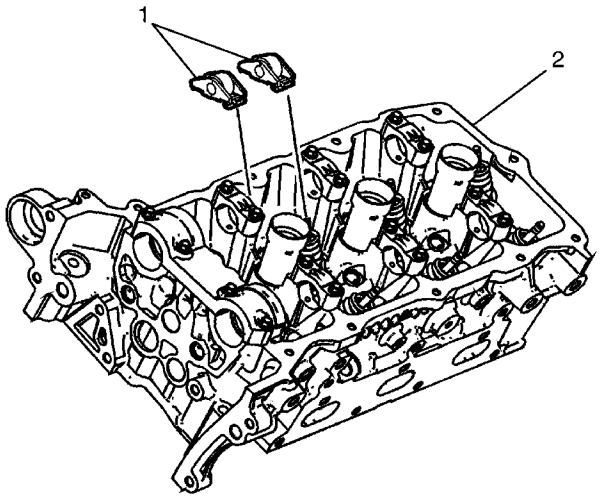


4. Remove the camshaft bearing cap to cylinder head retaining bolts (3).
5. Remove the camshaft bearing caps (1 and 2).



6. Remove the camshafts (1).

Valve Rocker Arm Removal - Left Side

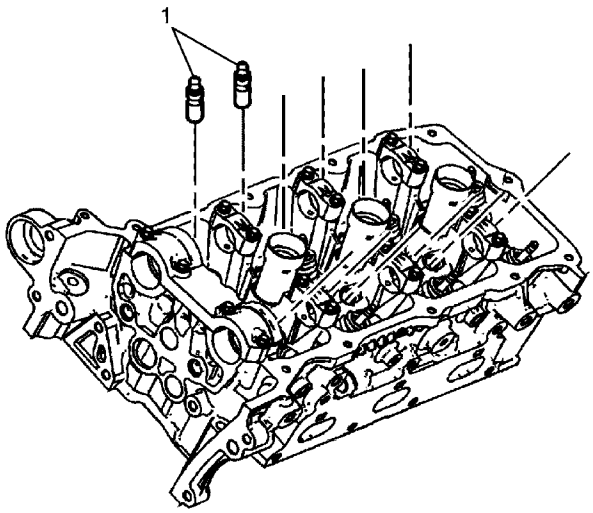


Important: The valve rocker arms (1) must be installed in their original locations.

1. Record the positions of the valve rocker arms (1).
2. Remove the valve rocker arms (1) from the cylinder head (2).

© 2010 General Motors Corporation. All rights reserved.

Valve Lifter Removal - Left Side



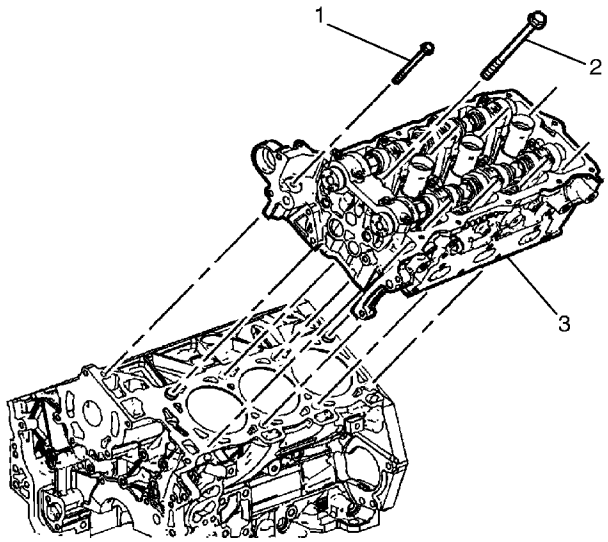
Important:

- DO NOT stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.
- DO NOT allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

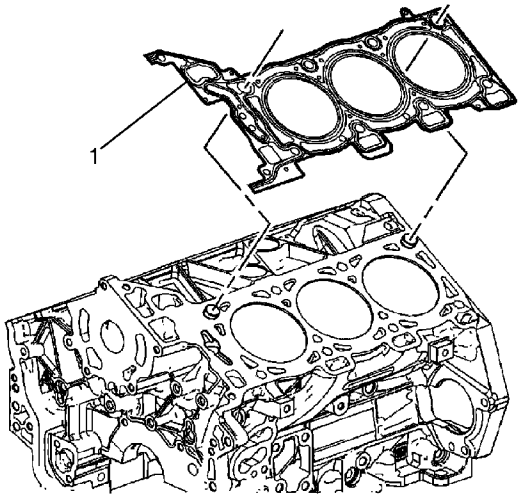
1. Remove the Stationary Hydraulic Lash Adjuster, (SHLAs) (valve lifters) (1).

© 2010 General Motors Corporation. All rights reserved.

Cylinder Head Removal - Left Side



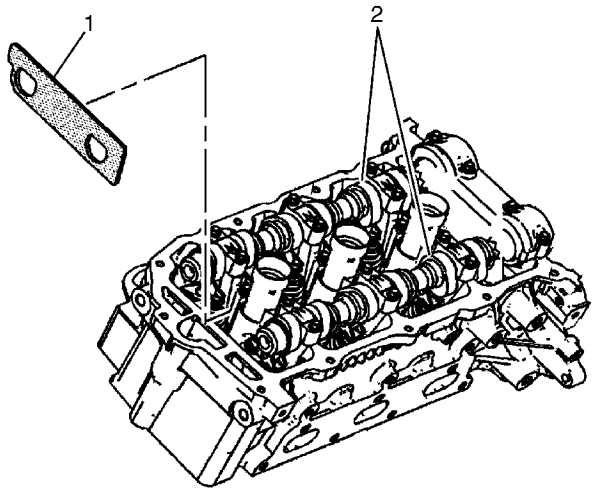
1. Remove the left bank cylinder head to cylinder block retaining bolts (1 and 2).
2. Remove the left bank cylinder head (3).



3. Remove and discard the left cylinder head gasket (1).

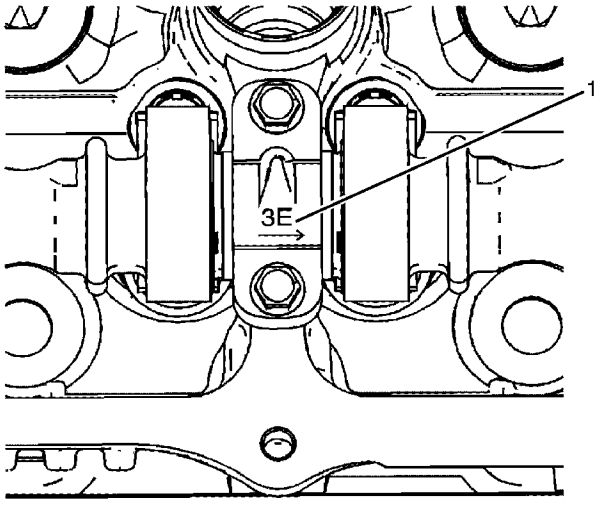
© 2010 General Motors Corporation. All rights reserved.

Camshaft Removal - Right Side



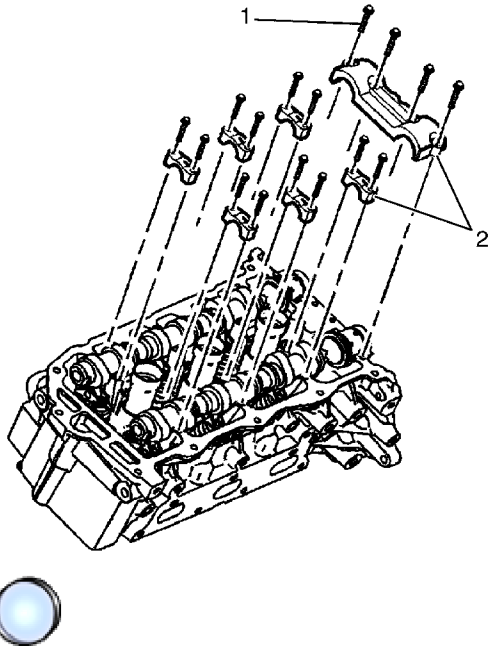
Important: EN 46105 (1) was installed to the camshafts (2) as part of the right bank cylinder head camshaft position actuator removal procedure.

1. Remove the EN 46105 (1) from the right bank camshafts (2).
2. Position the camshaft lobes in a neutral position.

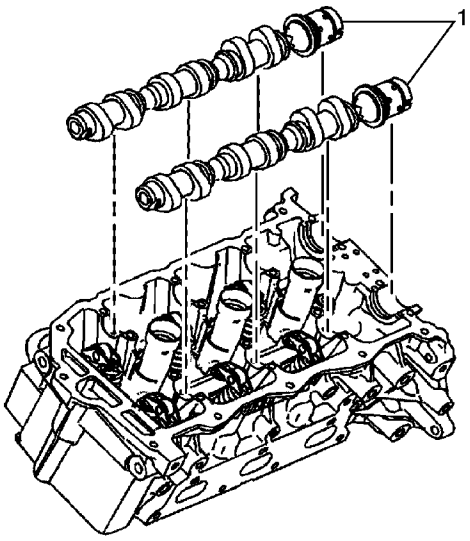


© 2010 General Motors Corporation. All rights reserved.

3. Observe the markings (1) on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the cylinder block.

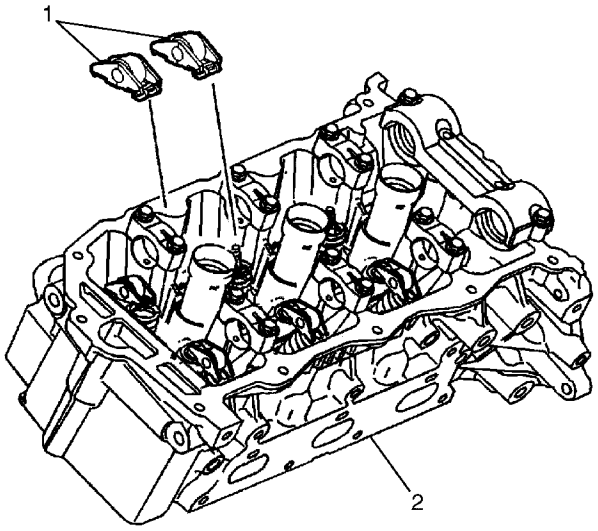


4. Remove the camshaft bearing cap to cylinder head retaining bolts (1).
5. Remove the camshaft bearing caps (2).



6. Remove the camshafts (1).

Valve Rocker Arm Removal - Right Side

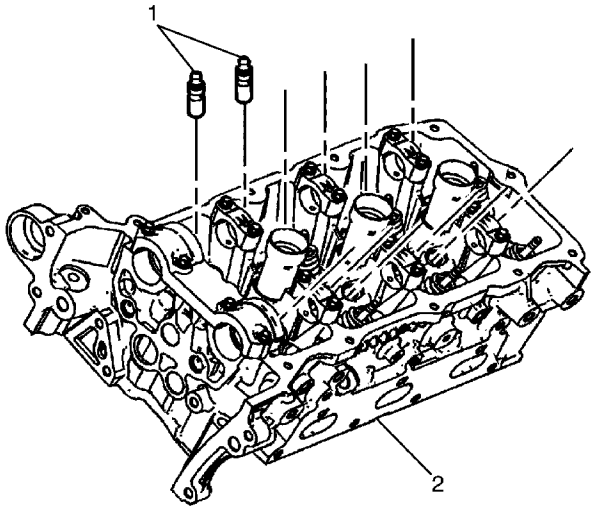


Important: The valve rocker arms (1) must be installed in their original locations.

1. Record the positions of the valve rocker arms (1).
2. Remove the valve rocker arms (1) from the right bank cylinder head (2).

© 2010 General Motors Corporation. All rights reserved.

Valve Lifter Removal - Right Side



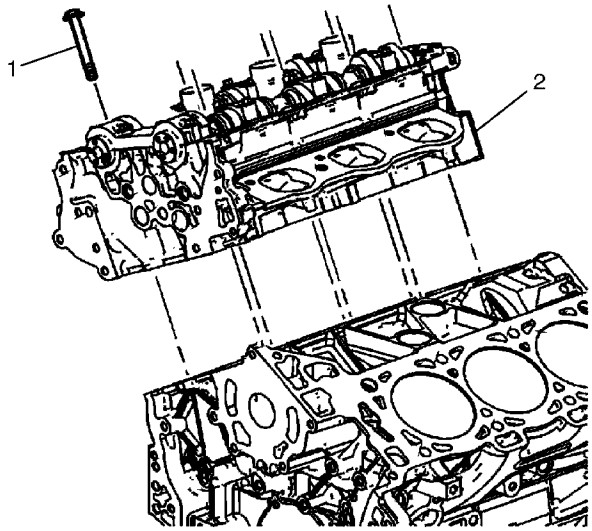
Important:

- DO NOT stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.
- DO NOT allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

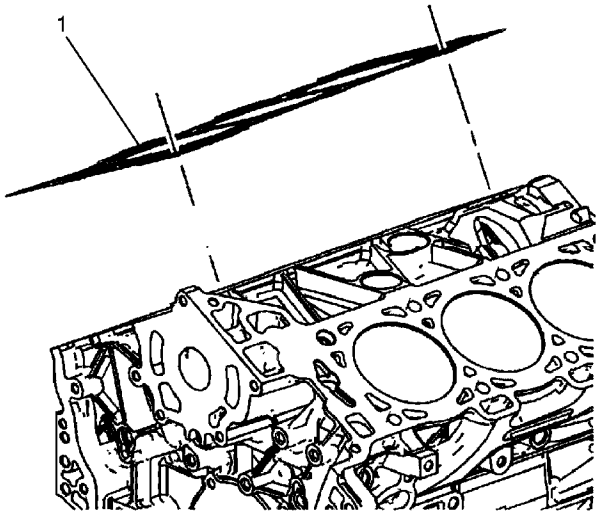
1. Remove the Stationary Hydraulic Lash Adjuster, (SHLAs) (valve lifters) (1) from the right bank cylinder head (2).

© 2010 General Motors Corporation. All rights reserved.

Cylinder Head Removal - Right Side



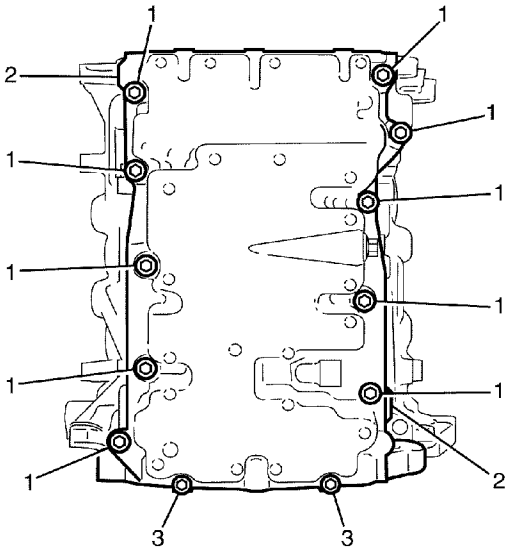
1. Remove the right bank cylinder head to cylinder block retaining bolts (1).
2. Remove the right bank cylinder head (2).



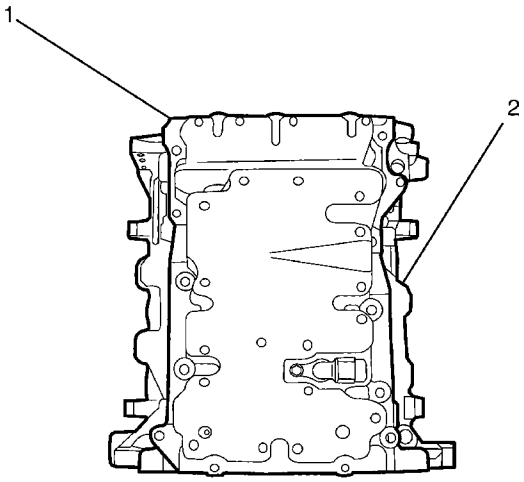
3. Remove and discard the right cylinder head gasket (1).

© 2010 General Motors Corporation. All rights reserved.

Oil Pan Removal



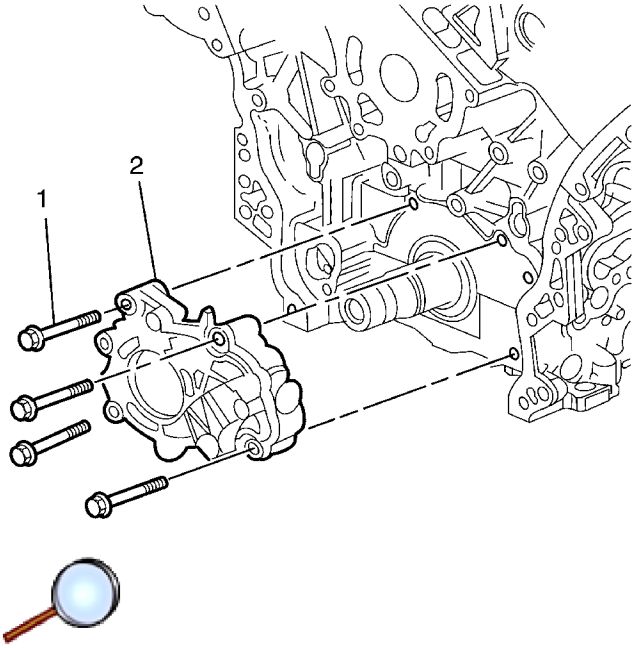
1. Remove the M8 oil pan to cylinder block retaining bolts (1).
2. Remove the M6 oil pan to crankshaft rear oil seal housing retaining bolts (3).
3. Using the pry points located at the edge of the oil pan (2) shear the RTV sealant.



4. Remove the oil pan (1) from the cylinder block (2).

© 2010 General Motors Corporation. All rights reserved.

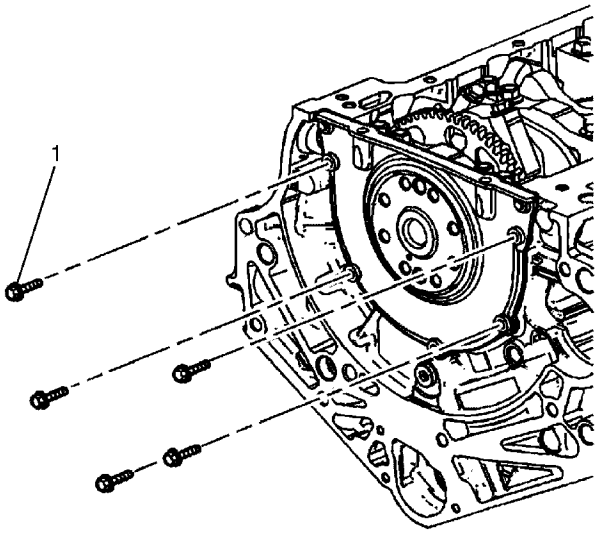
Oil Pump Removal



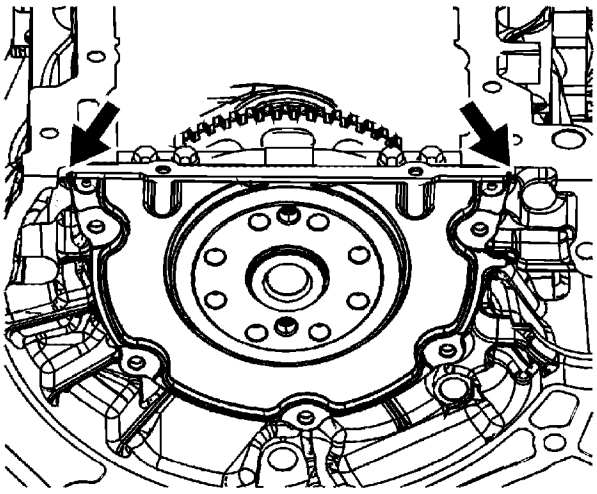
1. Remove the oil pump to cylinder block retaining bolts (1).
2. Remove the oil pump (2).

© 2010 General Motors Corporation. All rights reserved.

Crankshaft Rear Oil Seal and Housing Removal

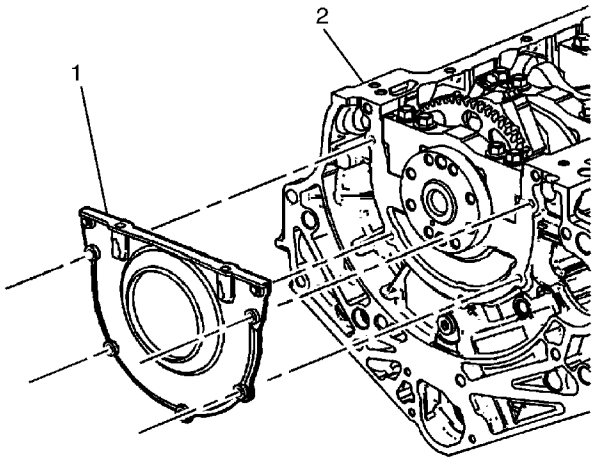


1. Remove the crankshaft rear oil seal housing bolts (1).



2. Using the pry points located at the edge of the crankshaft rear oil seal housing shear the RTV sealant.

© 2010 General Motors Corporation. All rights reserved.



3. Remove and discard the crankshaft rear oil seal housing (1) from the cylinder block (2).

Piston, Connecting Rod, and Bearing Removal

Special Tools

EN 46121 Connecting Rod Guide Pin Set

For equivalent regional tools, refer to Special Tools.

Note:

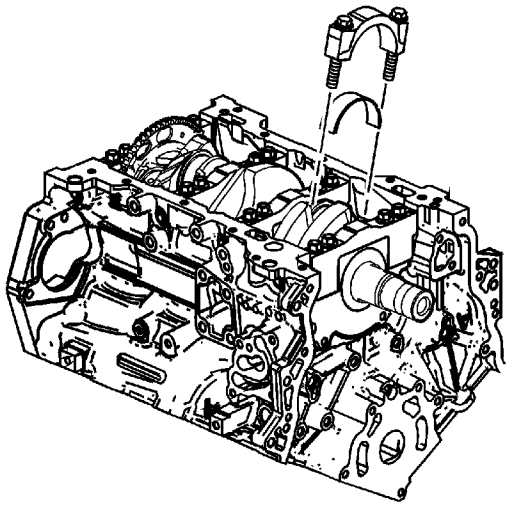
- An arrow/dot showing proper piston orientation is located on the top of the piston.
- If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
   1.1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
   1.2. Using feeler gages, measure the clearance between the crankshaft counterweight and the connecting rod.
   1.3. The connecting rod side clearance should not exceed specifications. Refer to Engine Mechanical Specifications.
   1.4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to Piston, Connecting Rod, and Bearing Cleaning and Inspection.
   1.5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
   1.6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

Caution: Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.

3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.

© 2010 General Motors Corporation. All rights reserved.

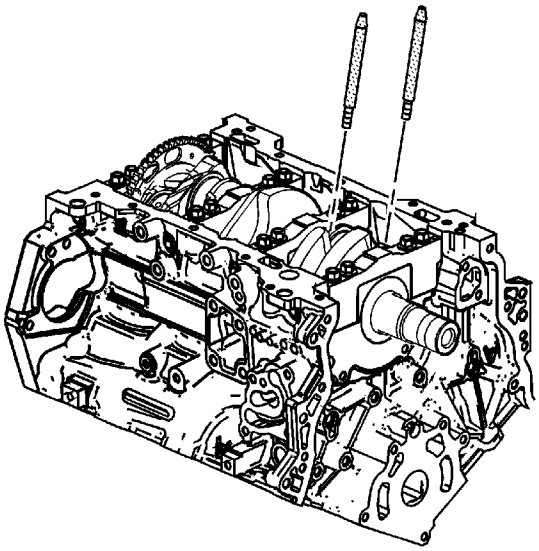


Caution: Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage.

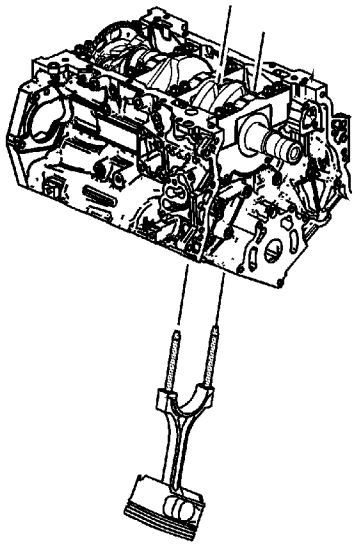
4. Remove the connecting rod bolts.

Note: The connecting rod caps must remain with the original connecting rod.

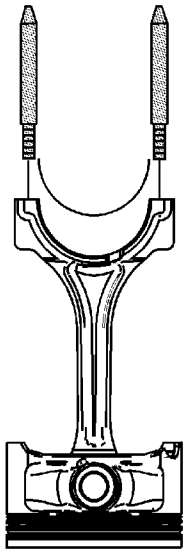
5. Remove the connecting rod cap.



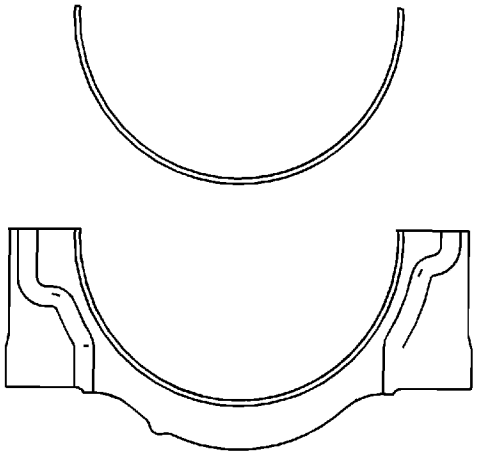
6. Install the *EN 46121* set into the connecting rod bolt holes.



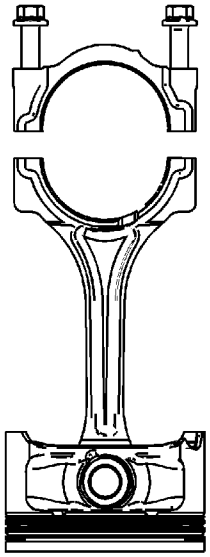
7. Using the *EN 46121* set , push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly.



8. Remove the *EN 46121* set from the connecting rod bolt holes.
9. Remove the upper connecting rod bearing from the connecting rod.



10. Remove the lower connecting rod bearing from the connecting rod cap.



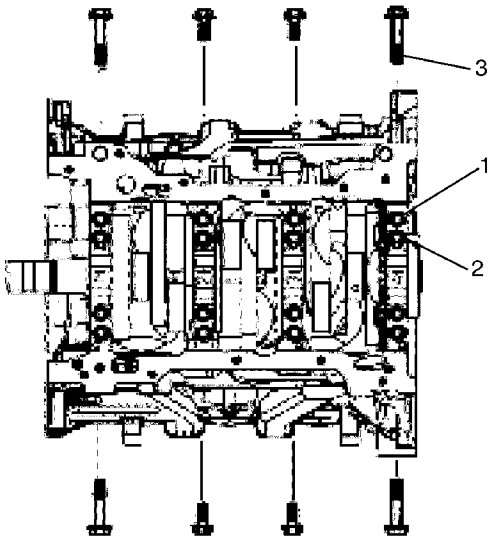
11. Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

Crankshaft and Bearing Removal

Special Tools

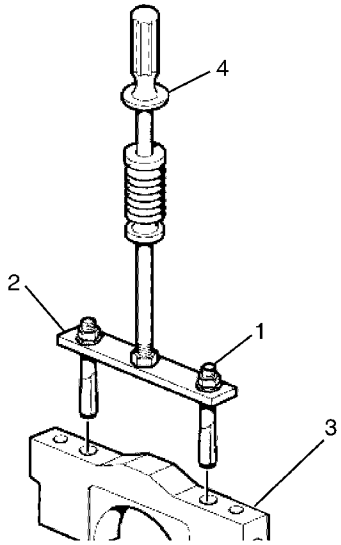
- *J 41818* Crankshaft Bearing Cap Remover
- *J 6125-1B* Slide Hammer with Adapter For equivalent regional tools, refer to Special Tools.

Crankshaft Removal



1. Remove the crankshaft bearing cap side bolts (3).
2. Remove the crankshaft bearing cap outer bolts (1).
3. Remove the crankshaft bearing cap inner bolts (2).

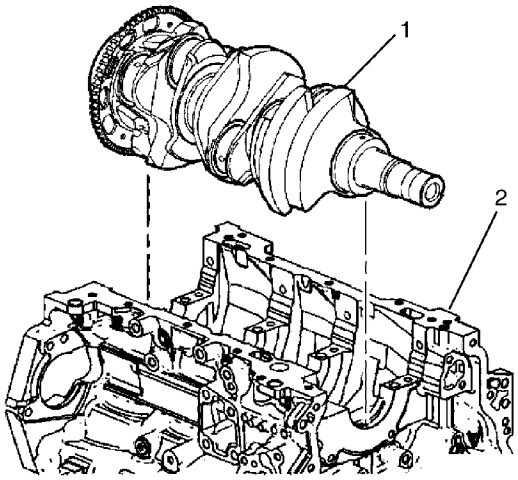
© 2010 General Motors Corporation. All rights reserved.



4. Install the *J 41818* remover (2) to the inner bolt holes of the crankshaft bearing cap (3).

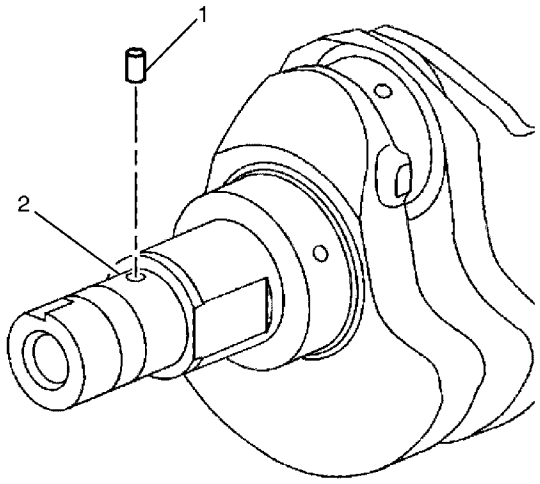
Caution: Refer to Fastener Caution in the Preface section.

5. Tighten the *J 41818* remover nuts (1) to **11 N·m (97 lb in)**.
6. Install the *J 6125-1B* adapter (4) onto the *J 41818* remover (2).
7. Remove the crankshaft bearing cap

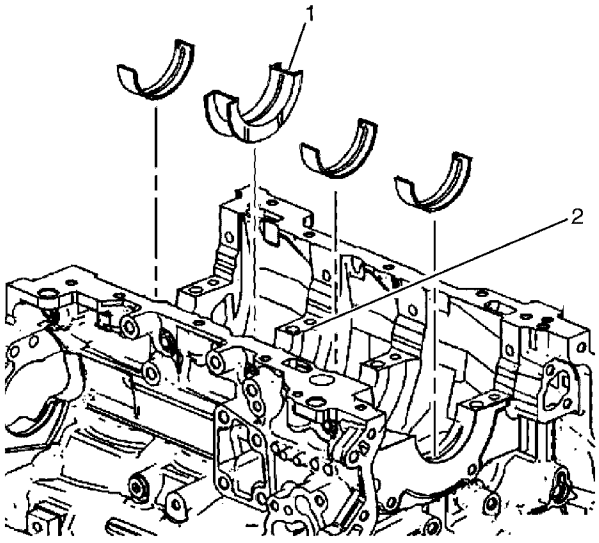


Note: Lift the crankshaft (1) straight up evenly to remove from the cylinder block (2).

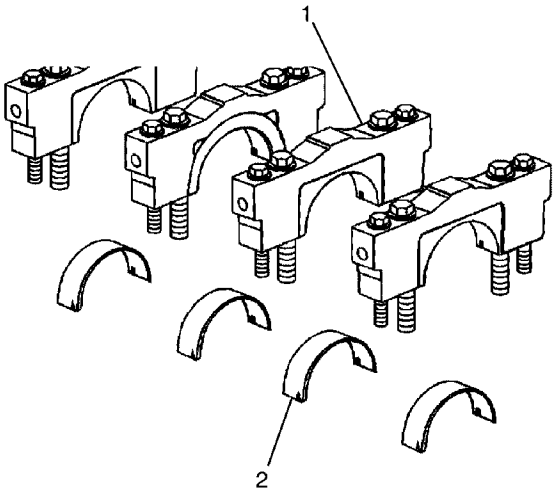
8. Remove the crankshaft (1).
9. Place the crankshaft in a secure place.



10. Remove the crankshaft sprocket drive pin (1) from the nose of the crankshaft (2), if required.
11. Prepare a piece of cardboard or equivalent, numbered 1-4 for bearing identification. Main bearing journals are numbered from the front of the cylinder block.

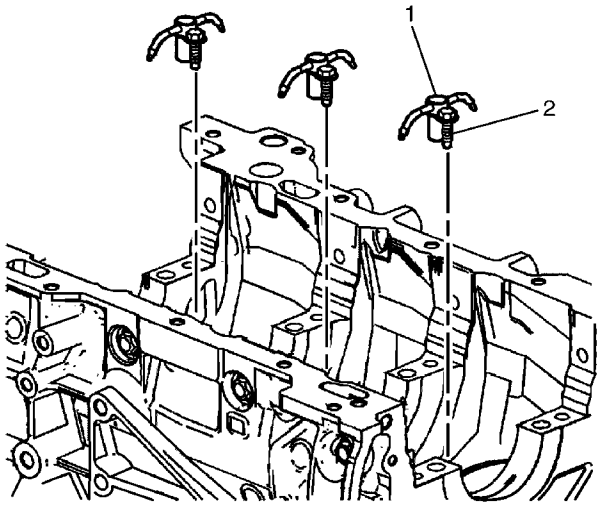


12. Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).
13. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.

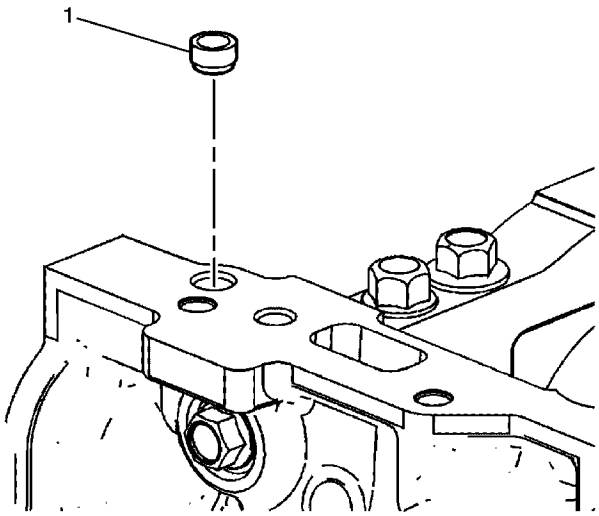


14. Remove the crankshaft lower bearing halves (2) from the crankshaft bearing caps (1).
15. Place the crankshaft lower bearing halves (2) in the correct positions on the cardboard.

Engine Block Disassemble

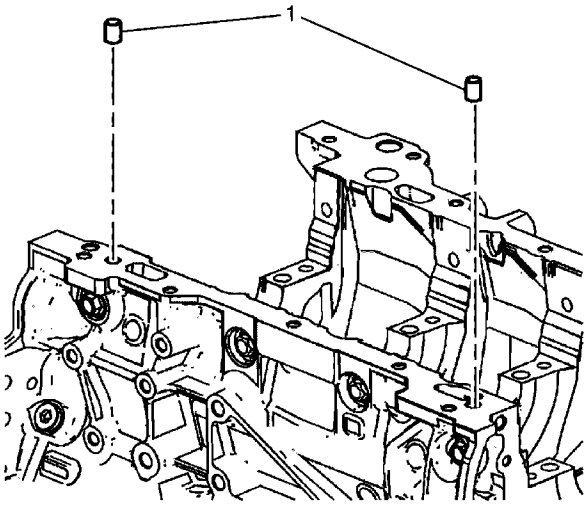


1. Remove oil jet to cylinder block retaining bolts (2).
2. Remove the oil jets (1).

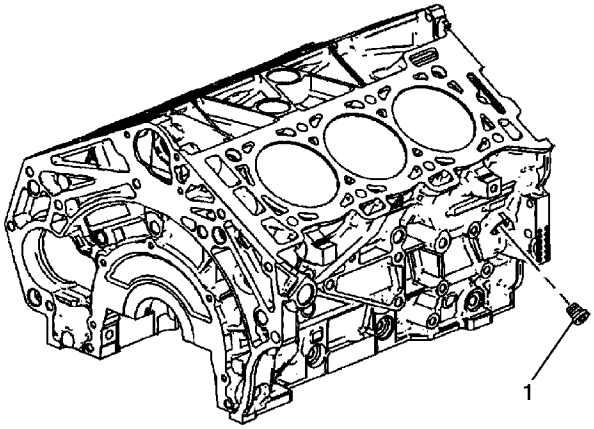


3. Remove the right front oil pan rail oil gallery expansion plug (1).

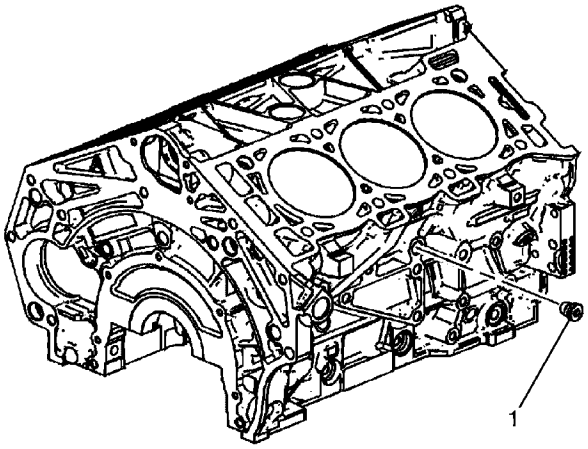
© 2010 General Motors Corporation. All rights reserved.



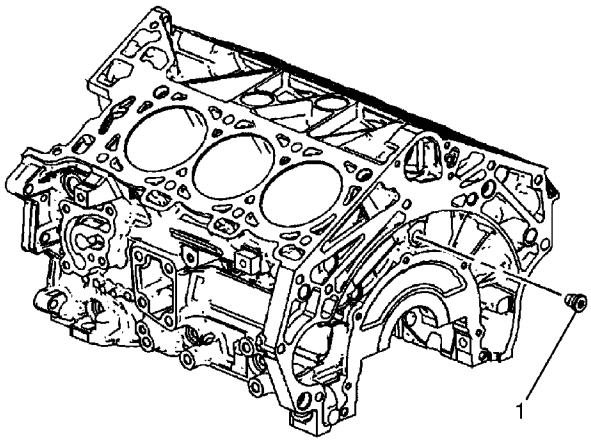
4. Remove the cylinder block-to-oil pan alignment dowels (1).



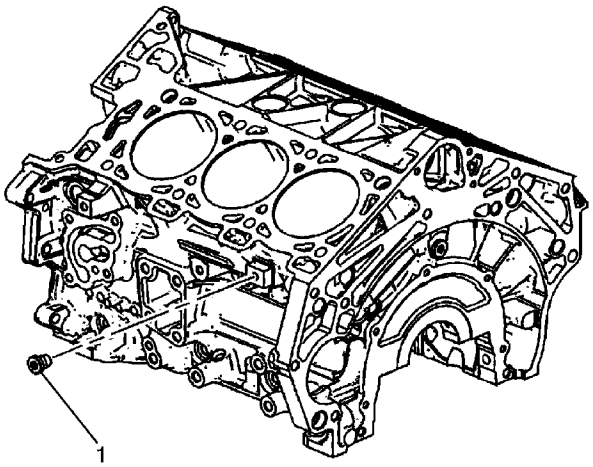
5. Remove the M14 right side oil gallery threaded plug (1).



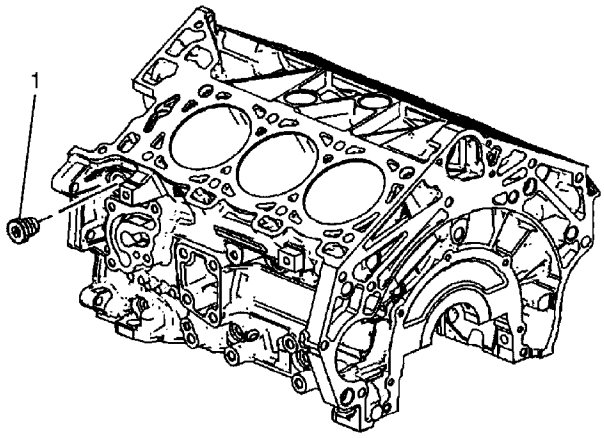
6. Remove the M14 right side coolant drain threaded plug (1).



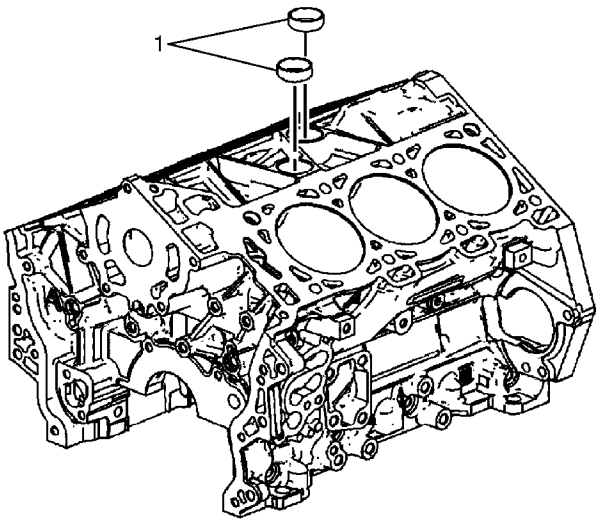
7. Remove the M14 rear oil gallery threaded plug (1).



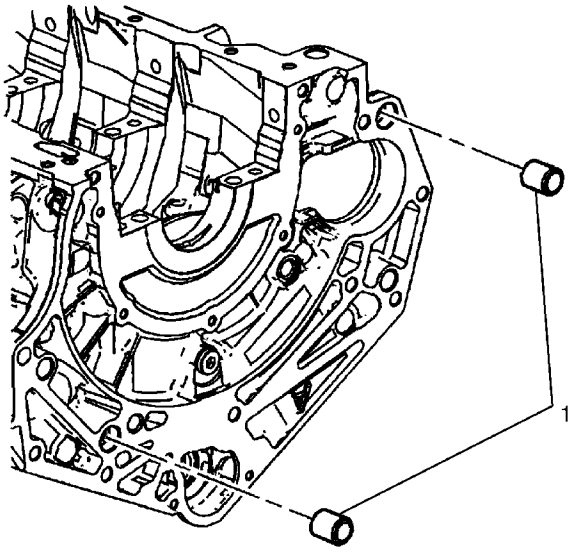
8. Remove the M14 left side coolant drain threaded plug (1).



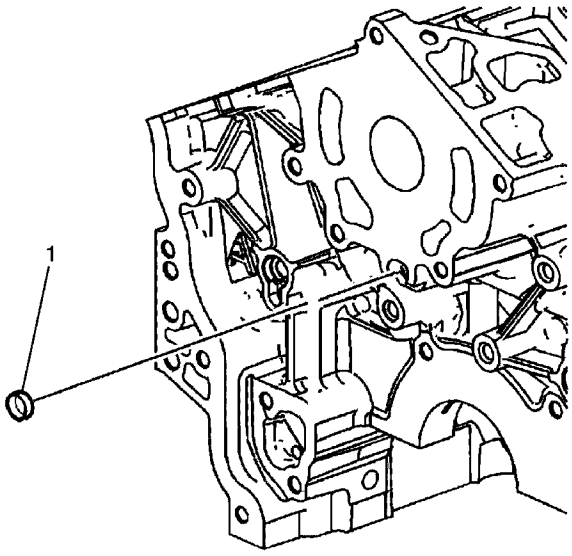
9. Remove the M20 left side oil gallery threaded plug (1).



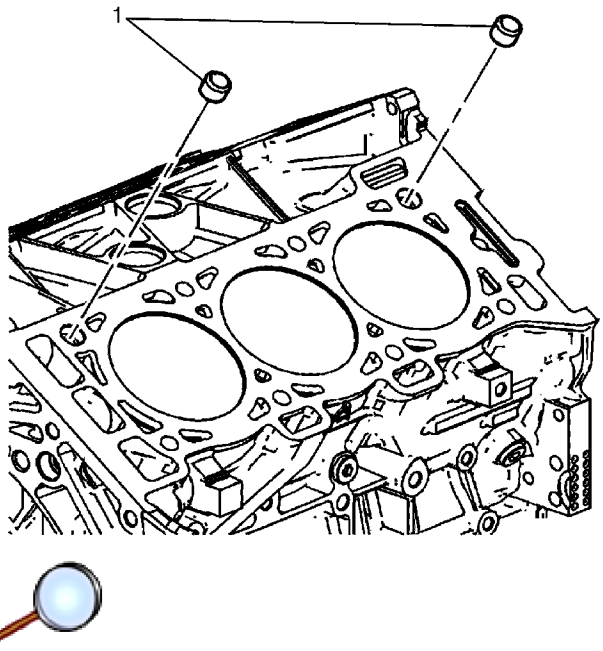
10. Remove the coolant expansion plugs (1).



11. Remove the cylinder block-to-transmission alignment dowels (1).



12. Remove the front oil gallery expansion plug (1).



13. Remove the cylinder block-to-cylinder head alignment dowels (2).

Engine Block Cleaning and Inspection

Special Tools

- *J 8087* Cylinder Bore Gage
- *J 28410* Gasket Remover

For equivalent regional tools, refer to Special Tools.

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using *J 28410* remover .
2. Clean all the following areas with solvent:
   - Sealing surfaces
   - Cooling passages
   - Oil passages
   - Bearing journals
3. Clean all threaded and through holes with solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

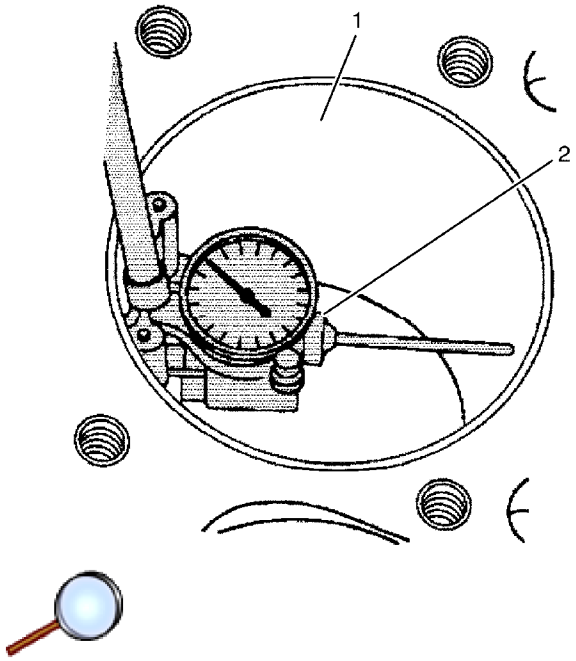
4. Dry the cylinder block with compressed air.

Visual Inspection

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the primary camshaft drive chain tensioner mounting surface on the cylinder block for burrs or any defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or debris above acceptable tolerances.
5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
6. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
7. Inspect the cylinder block for cracks. DO NOT repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to Thread Repair Specifications and Thread Repair.

Measuring Cylinder Bore Diameter

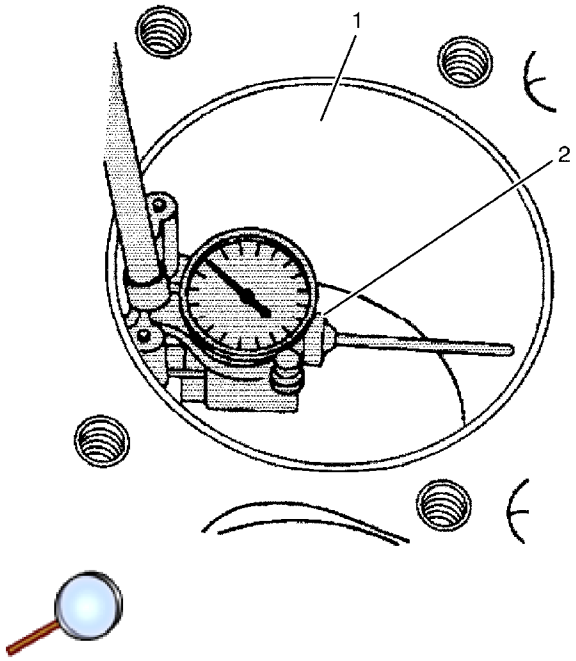
© 2010 General Motors Corporation. All rights reserved.



1. Measure the cylinder bore diameter 42 mm (1.654 in) from the deck face (1) using the *J 8087* gage (2).
2. Record and compare your results with the Engine Mechanical Specifications. If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

   If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

Measuring Cylinder Bore Taper

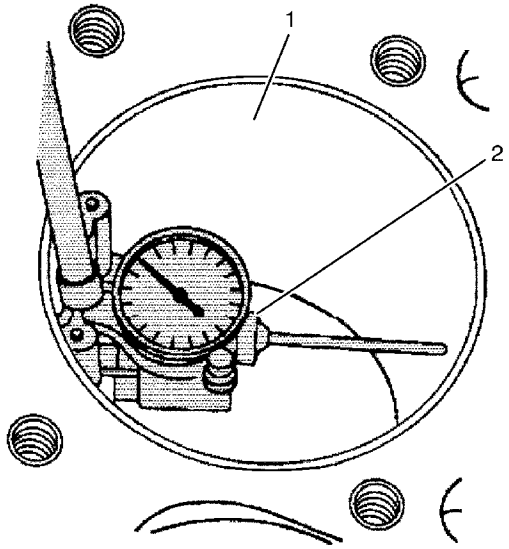


1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft

centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the Engine Mechanical Specifications. If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

   If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

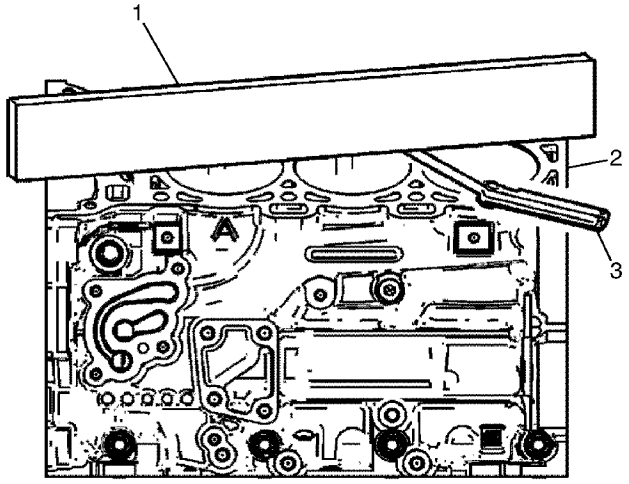
Measuring Cylinder Bore Out-of-Round



1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the Engine Mechanical Specifications. If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

   If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

Deck Flatness Inspection



1. Make sure the cylinder block decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that may inhibit correct cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder block deck face surface.
4. Measure the clearance between the straight-edge and the cylinder block deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder block deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that may inhibit correct cylinder head gasket sealing are present, the cylinder block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

Crankshaft and Bearing Cleaning and Inspection

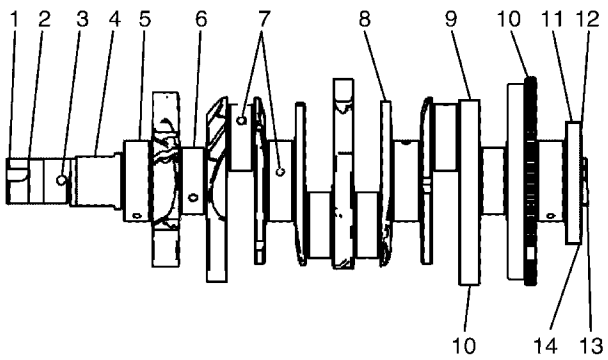
Cleaning Procedure

1. Clean the following components in solvent:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals
   - Crankpin journals
   - Crankshaft oil passages
   - Crankshaft threaded holes

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the following components with compressed air:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals
   - Crankpin journals
   - Crankshaft oil passages
   - Crankshaft threaded holes

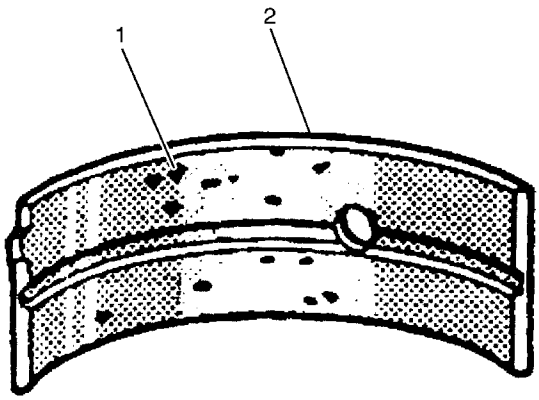
Visual Inspection



© 2010 General Motors Corporation. All rights reserved.

1. Perform the following visual inspections:
   - Inspect the crankshaft balancer bolt hole (1) for thread damage.
   - Inspect the crankshaft balancer mounting area (2) for damage.
   - Inspect the crankshaft sprocket pin hole (3) for damage.
   - Inspect the oil pump drive flats (4) for damage.
   - Inspect the crankshaft main journals (5) for damage.
   - Inspect the crankshaft connecting rod journals (6) for damage.
   - Inspect the crankshaft oil passages (7) for obstructions.
   - Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
   - Inspect the crankshaft counterweights (9) for damage.
   - Inspect the crankshaft reluctor ring teeth (10) for damage.
   - Inspect the crankshaft rear main oil seal surface (11) for damage.
   - Inspect the crankshaft engine flywheel mounting surface (12) for damage.
   - Inspect the crankshaft pilot hole (13) for damage.
   - Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.
2. Repair or replace the crankshaft as necessary.

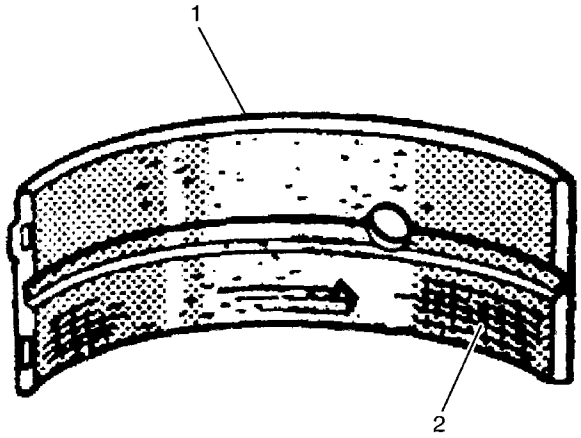
Crankshaft Bearing Inspection



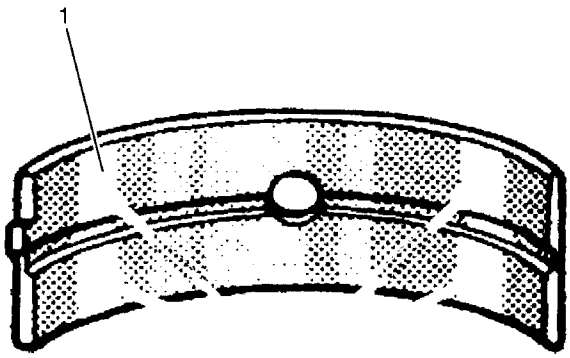
Note:
- All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.
- The following bearing wear conditions should be used to diagnose engine operating

conditions or root cause of a condition.

1. Inspect for fatigue indicated by craters or pockets (1). Flattened sections on the bearing halves (2) also indicate fatigue.

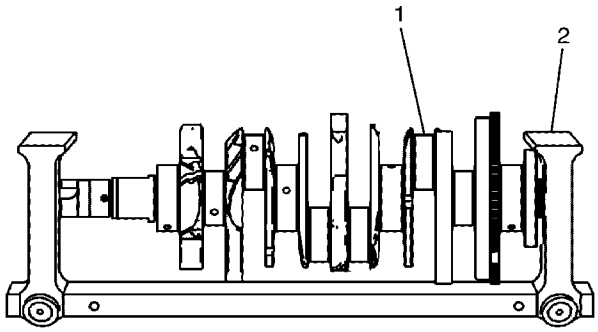


2. Inspect for scoring above acceptable tolerances or discoloration (2) on both front and back of the bearing halves (1).
3. Inspect the main bearings for dirt embedded into the bearing material.

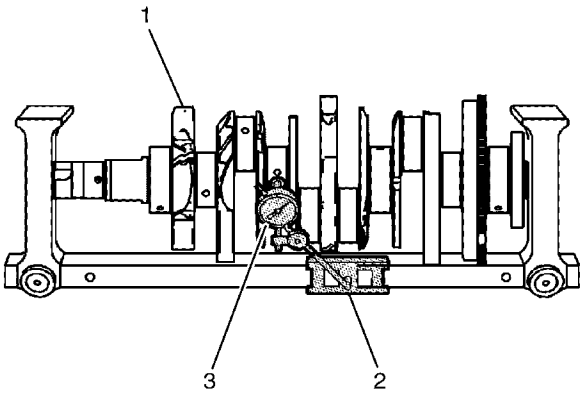


4. Inspect for incorrect seating indicated by bright, polished sections (1).

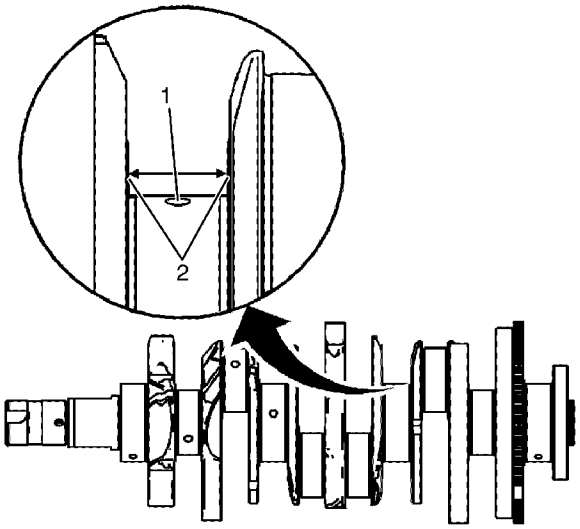
Crankshaft Measurement



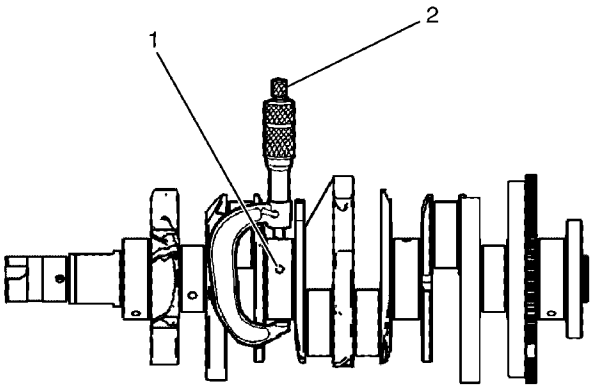
1. Using a suitable fixture (2), support the crankshaft (1).



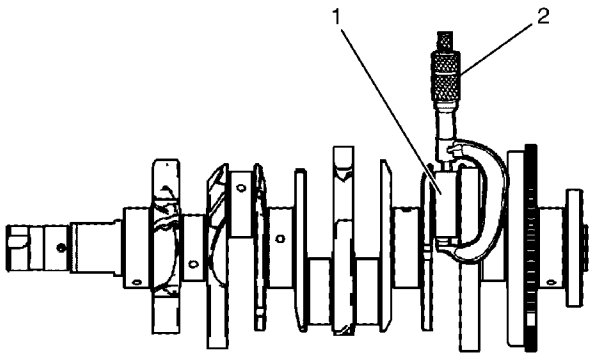
2. Set up a dial indicator (3) and magnetic base (2).
3. Rotate the crankshaft (1) to measure and record the crankshaft runout. Compare your results with the Engine Mechanical Specifications.



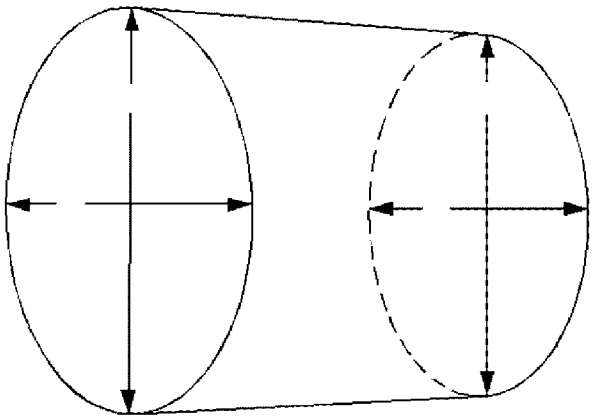
4. Measure and record the crankshaft thrust wall width (2) for wear using an inside micrometer. Compare your results with the Engine Mechanical Specifications.
5. Measure and record the crankshaft thrust wall surface (1) for runout using the dial indicator. Compare your results with the Engine Mechanical Specifications.
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.



7. Inspect the crankshaft main journals (1) for undersize, using an outside micrometer (2).



8. Inspect the crankpins (1) for undersize using an outside micrometer (2).
9. Compare your results with the Engine Mechanical Specifications. If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.



10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
    10.1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
    10.2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
    10.3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
    10.4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.

10.5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

11. Measure the main bearing and crankpin journals for taper using the following procedure:

11.1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.

11.2. Subtract the smallest from the largest measurement. The result will be the journal taper.

11.3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.

11.4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

Crankshaft Balancer Cleaning and Inspection

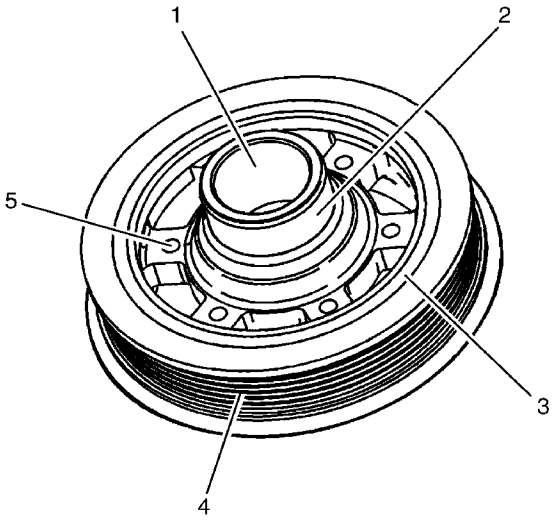
Cleaning Procedure

1. Clean the crankshaft balancer in solvent that is compatible with the rubber.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the crankshaft balancer with compressed air.

Inspection Procedure



1. Inspect the crankshaft balancer for the following:
   - Worn or damaged hub-to-crankshaft surface (1)
   - Worn, grooved or damaged hub seal surface (2).
   - Worn, chunking or deteriorated rubber between the hub and pulley (3)
   - Damaged drive belt ribs (4)
   - Damaged threaded holes (5)
2. Repair or replace the crankshaft balancer as required.

© 2010 General Motors Corporation. All rights reserved.

Engine Flywheel Cleaning and Inspection

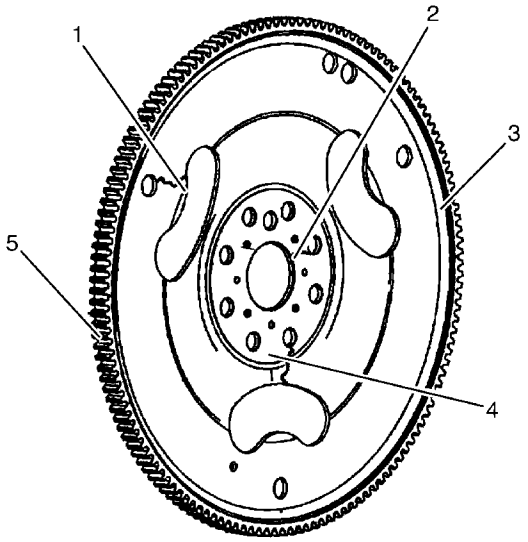
Cleaning Procedure

1. Clean the engine flywheel in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the engine flywheel with compressed air.

Inspection Procedure



1. Inspect the engine flywheel for the following conditions:
   - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2 and 4)

     Note: DO NOT attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a new engine flywheel.

   - Cracks at welded areas that retain the ring gear onto the engine flywheel (3)
   - Damaged or missing ring gear teeth (5)
2. Replace the engine flywheel as necessary.

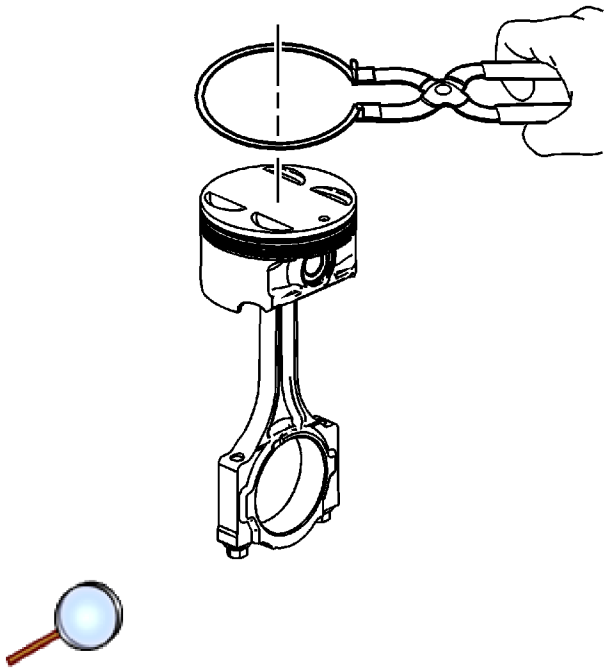
© 2010 General Motors Corporation. All rights reserved.

Piston and Connecting Rod Disassemble

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

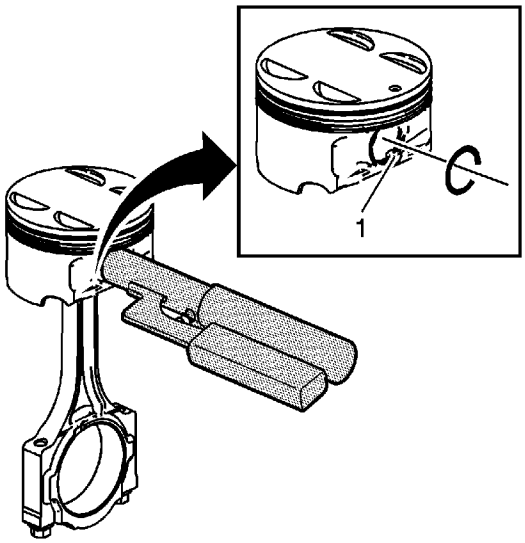
For equivalent regional tools, refer to Special Tools.



Caution: You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.

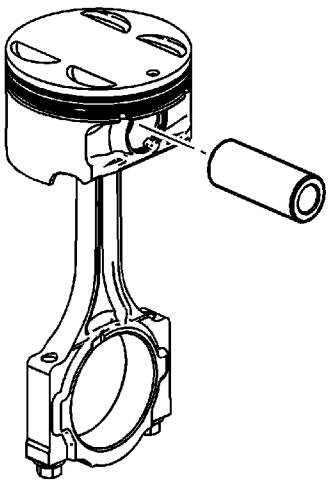
© 2010 General Motors Corporation. All rights reserved.



Note:

- The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.
- DO NOT reuse the piston pin retainers.

2. Using the *EN-46745* remover/installer , remove the piston pin retainers by using the removal access notch (1) in the side of the piston. Discard the piston pin retainers.



3. Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

Piston, Connecting Rod, and Bearing Cleaning and Inspection

Cleaning Procedure

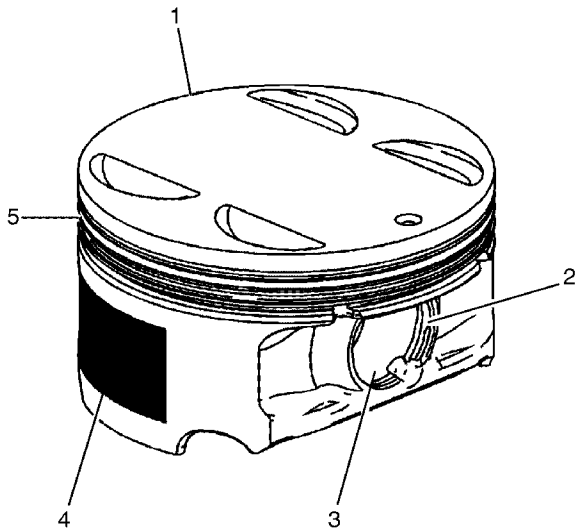
Note: DO NOT wire brush any part of the piston.

1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

Warning: Refer to Safety Glasses Warning in the Preface section.

3. Dry the piston with compressed air.

Piston Inspection Procedure

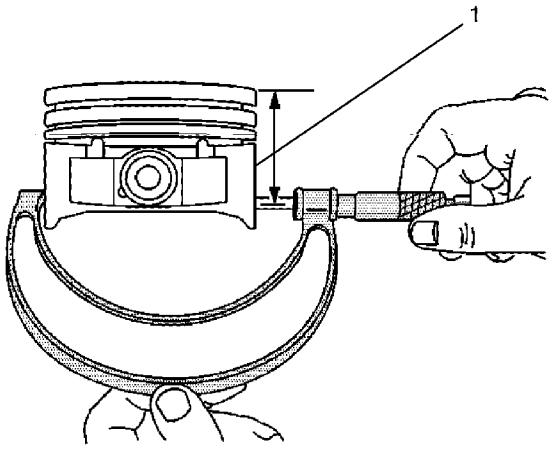


1. Inspect the pistons for the following conditions:
   - Cracked ring lands, skirts or pin bosses
   - Ring grooves for nicks, burrs that may cause binding (5)
   - Warped or worn ring lands (5)
   - Piston pin retainer grooves for burrs (2)
   - Eroded areas at the top of the piston (1)
   - Scuffed or damaged skirt coating (4)
   - Worn piston pin bores or worn piston pins (3)

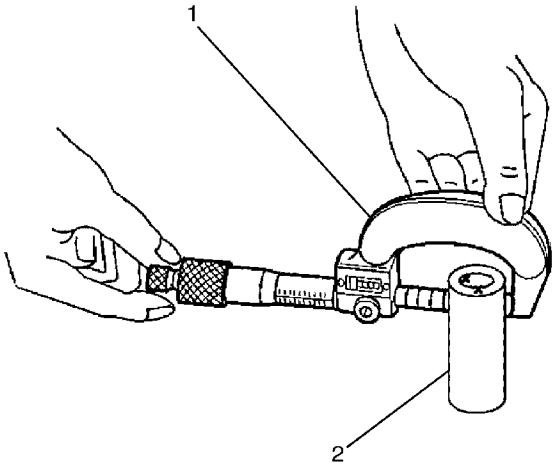
© 2010 General Motors Corporation. All rights reserved.

2. Replace pistons that show any signs of damage or wear above acceptable tolerances.

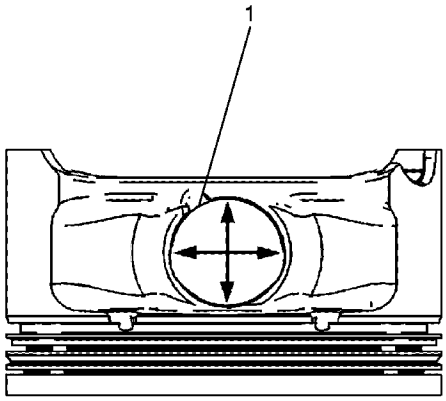
Piston Measurement Procedure



1. Measure piston width using the following procedure:
   1.1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top (1), at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
   1.2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
   1.3. Compare your results with the Engine Mechanical Specifications.
   1.4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.

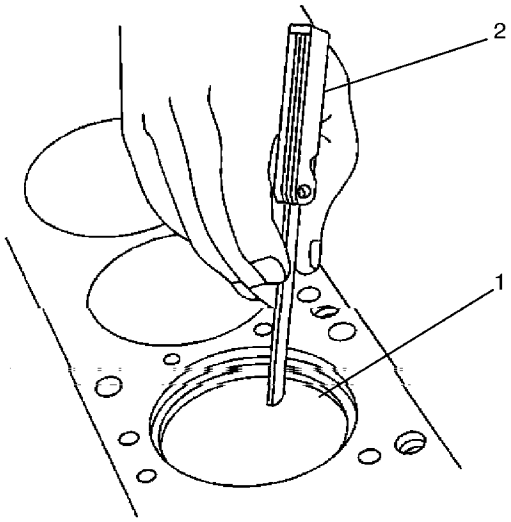


2. Measure the piston pin bore to piston pin (2) clearances using the following procedure:
   2.1. Piston pin bores and pins must be free of varnish or scuffing.
   2.2. Use an outside micrometer (1) to measure the piston pin in the piston contact areas.

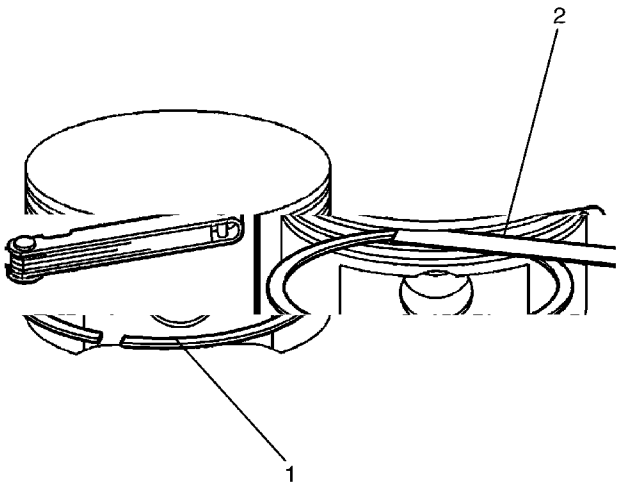


3. Using an inside micrometer, measure the piston pin bore (1). Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the Engine Mechanical Specifications.
4. If the clearance is above acceptable tolerances, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

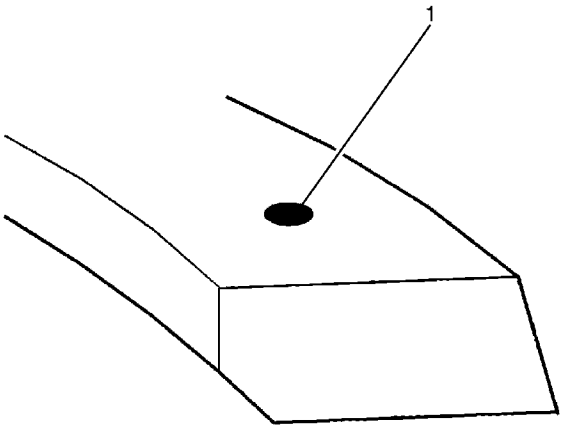
Piston Ring Measurement Procedure



1. Measure the piston ring end gap using the following procedure:
   1.1. Place the piston ring (1) in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Make sure that the piston ring (1) is square with the cylinder bore by positioning the piston ring (1) with the piston head.
   1.2. Measure the end gap of the piston ring (1) with feeler gauges (2). Refer to Engine Mechanical Specifications.
   1.3. If the clearance exceeds the provided specifications, the piston rings (1) must be replaced.
   1.4. Repeat the procedure for all the piston rings (1).



2. Measure the piston ring (1) side clearance using the following procedure:
   2.1. Roll the piston ring (1) entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring (1), replace the piston ring (1).
   2.2. With the piston ring (1) on the piston, use feeler gauges (2) to check clearance at multiple locations.
   2.3. Compare the measurements with piston ring side clearance listed in the Engine Mechanical Specifications.
   2.4. If the clearance is greater than specifications, replace the piston ring (1).



3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.
4. If the new ring does not reduce the clearance to the correct specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

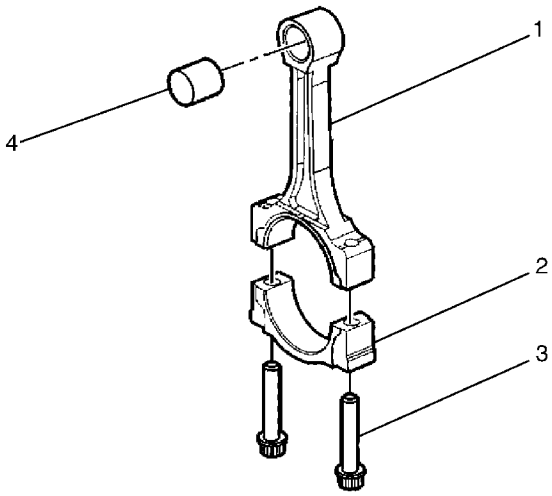
Connecting Rod Cleaning Procedure

1. Clean the connecting rods in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure



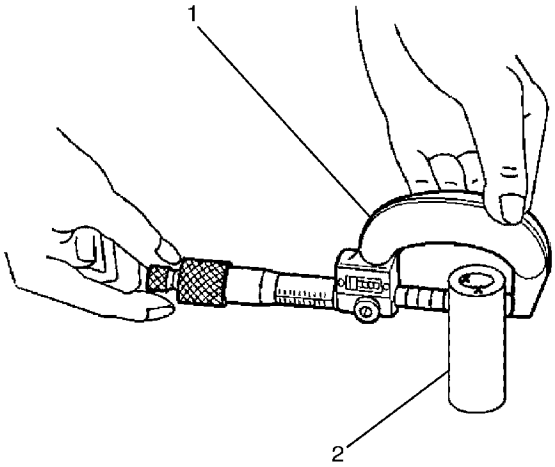
1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

   Note: DO NOT scrape the rod or rod cap.

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.
6. Inspect the connecting rod bolts (3) for damage or stretching.

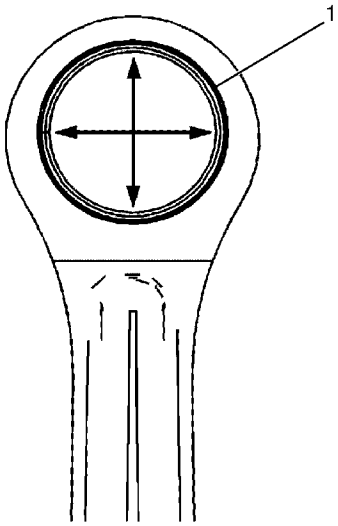
Connecting Rod Measurement Procedure

Piston Pin End



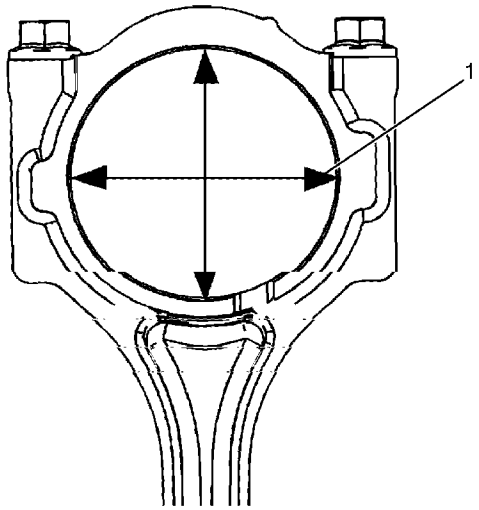
Note: Measurements of all components should be taken with the components at normal room temperature.

1. Using an outside micrometer (1), take 2 measurements of the piston pin (2) in the area of the connecting rod contact.



2. Using an inside micrometer, measure the connecting rod piston pin bore (1).
3. Subtract the piston pin diameter from the piston pin bore (1).
4. Compare the clearance measurements with the Engine Mechanical Specifications.
5. If the clearance is above acceptable tolerances, replace the piston pin. If a new pin does not resolve the clearance condition, replace the connecting rod.

Connecting Rod Crankshaft Bearing End



Note: Measurements of all components should be taken with the components at normal room temperature.

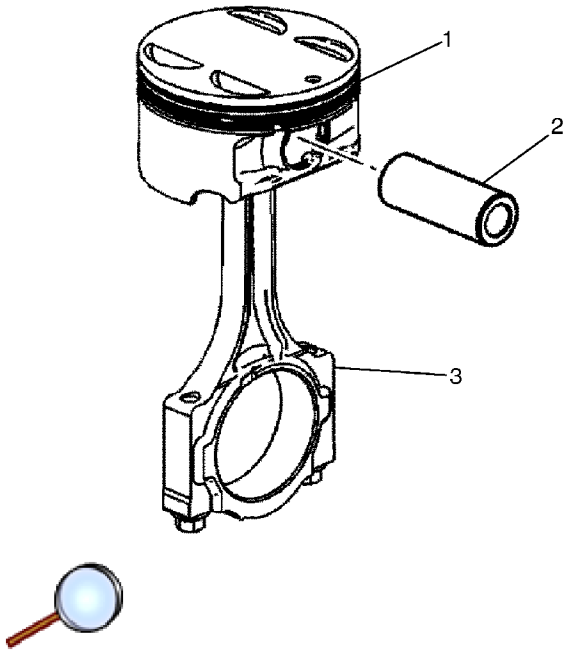
1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore (1).
2. Compare the bore measurements with the Engine Mechanical Specifications.
3. Replace the connecting rod if the connecting rod crankshaft bearing bore (1) is out of specifications. DO NOT recondition the connecting rod.

Piston and Connecting Rod Assemble

Tools Required

- EN 46121 Connecting Rod Guide Pin Set
- EN-46745 Piston Pin Clip Remover/Installer

Piston and Piston Pin Installation Procedure

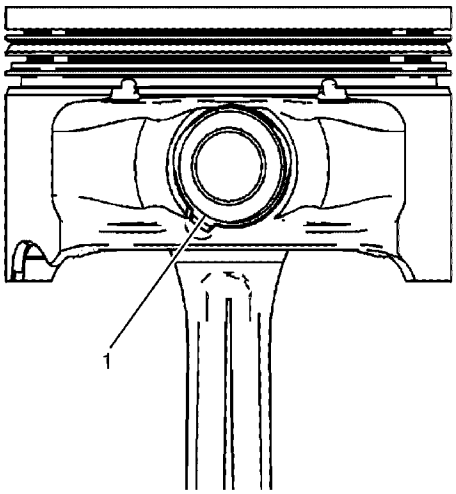


Important:

- The arrow located on top of the piston must point toward the front of the cylinder block.
- The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.

1. Lubricate the piston pin (2) bores in the piston (1) and the connecting rod (3) with clean engine oil.
2. Assemble the piston (1) and piston pin (2) to the connecting rod (3). Correctly orient the piston (1) when reusing a marked connecting rod (3).
3. Align the piston pin (2) bore with the connecting rod (1) pin bore.
4. Slide the piston pin (2) into the piston (1) and the connecting rod (3).

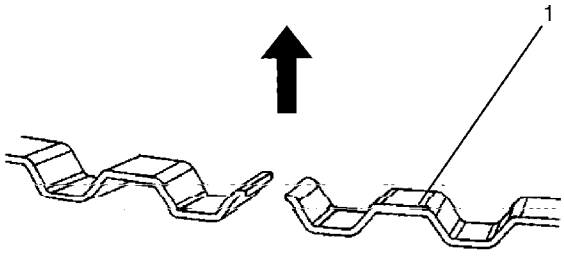
© 2010 General Motors Corporation. All rights reserved.



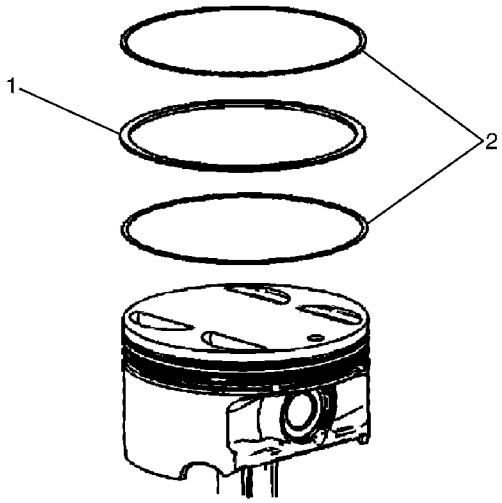
Important: New piston pin retainers must be used. Never reuse the piston pin retainers.

5. Install NEW piston pin retainers using the EN-46745 . Align the EN-46745 to the notch (1) in the piston.
6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

Piston Ring Installation Procedure



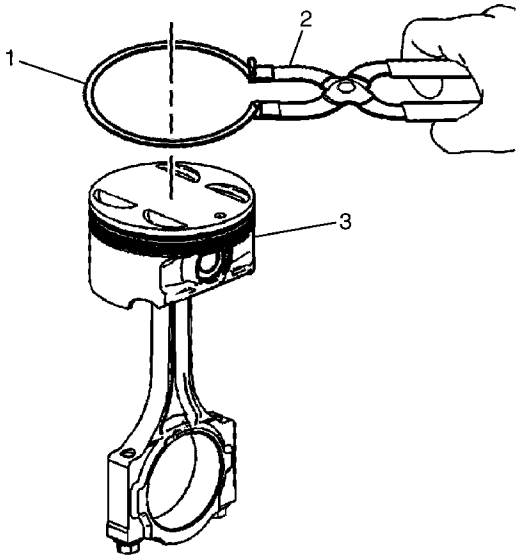
1. Correctly orient the oil control ring expander (1) as shown before installation. The ends of the oil control ring expander (1) must be facing toward the top of the piston.



2. Using a piston ring expander, install the oil control ring assembly using the following procedure:
   2.1. Install the expander ring (1).

Important: Make sure that you DO NOT overexpand the piston ring. Overexpanding the piston rings will distort or crack the rings.

   2.2. Install the 2 oil scraper rings (2). Expand the rings only enough to clear the piston diameter.

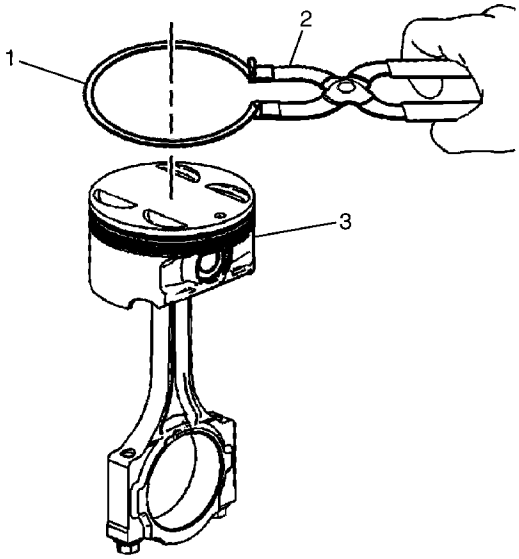


Important: Make sure that you DO NOT overexpand the piston ring. Overexpanding the

piston rings will distort or crack the rings.

Important: Install the second piston ring (1) onto the piston (3) using the ring expander (2).

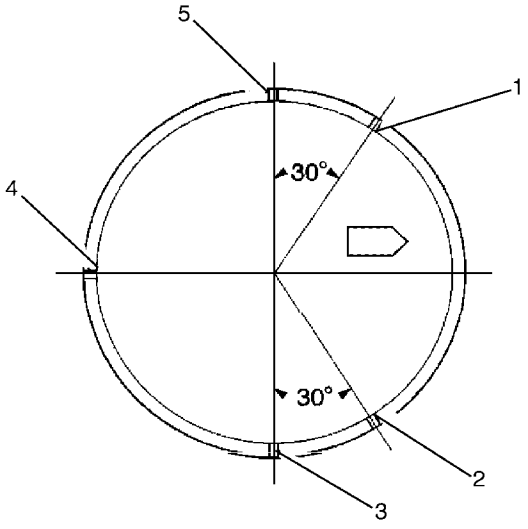
3. Install the second piston ring (1) onto the piston (3).



Important: Make sure that you DO NOT overexpand the piston ring. Overexpanding the piston rings will distort or crack the rings.

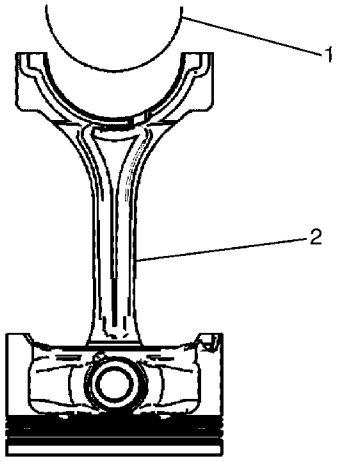
Important: Install the top piston ring (1) onto the piston (3) using the ring expander (2).

4. Install the top piston ring (1) onto the piston (3).



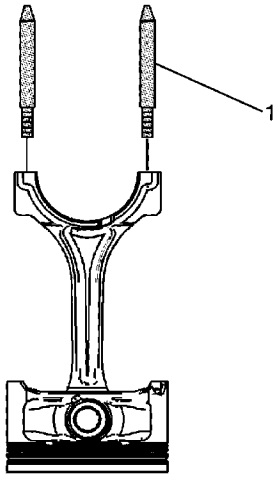
5. Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.
   5.1. Lower oil control ring - position (1).
   5.2. Upper oil control ring - position (2).
   5.3. Top Ring - position (3).
   5.4. Oil control ring expander - position (4).
   5.5. Second ring - position (5).

Connecting Rod Bearing Installation Procedure

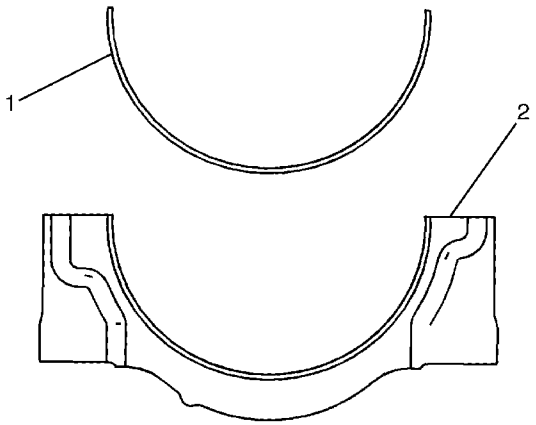


Important: If the connecting rod bearings (1) have been used in a running engine, you must replace them with NEW connecting rod bearings (1) for reassembly.

1. Clean the connecting rod (2) and the connecting rod cap bearing bore with a lint-free cloth.
2. Clean all the oil from behind the connecting rod bearing (1) halves.
3. Install new upper connecting rod bearings (1) into position. Roll the connecting rod bearings (1) into position so that the lock tang engages the alignment slot. The connecting rod bearings (1) must fit flush in the connecting rod (2).



4. Install the EN 46121 (1) into the connecting rod bolt holes.



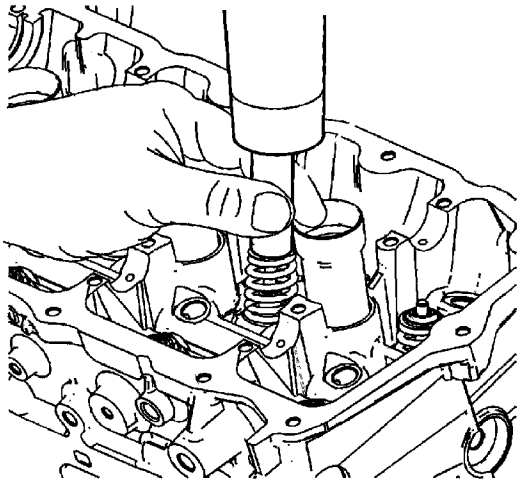
5. Install new lower connecting rod bearings (1) into position in the connecting rod cap (2). Roll the connecting rod bearings (1) into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap (2).

Cylinder Head Disassemble

Special Tools

- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Stem Key Remover/Installer
- *EN 46119* Off-Vehicle Valve Spring Compressor Adapter
- *EN-46122* Camshaft Position Actuator Check-Ball Valve Remover/Installer
- *J 8062* Valve Spring Compressor - Head Off

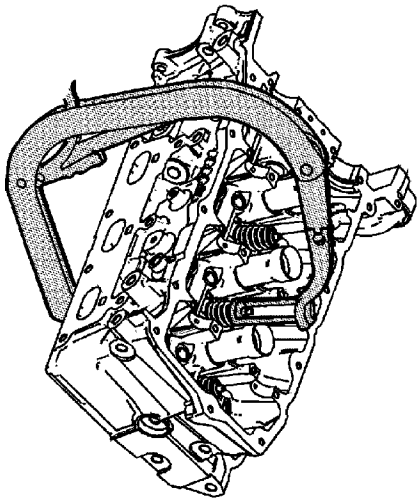
For equivalent regional tools, refer to Special Tools.



Note: Make sure valve heads will not contact anything during the following step in order to avoid bending or damage.

1. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve collets.

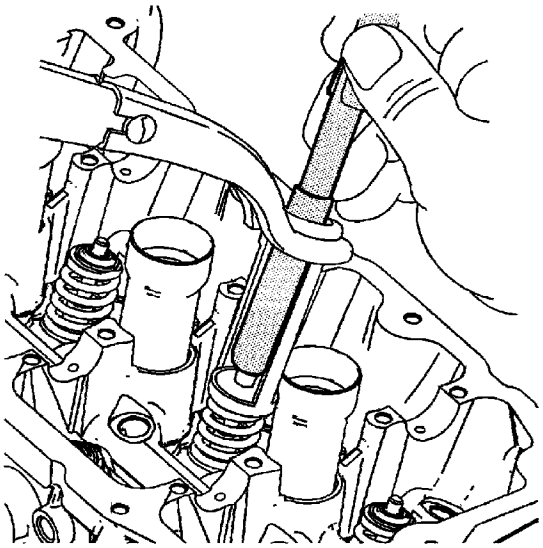
© 2010 General Motors Corporation. All rights reserved.



Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

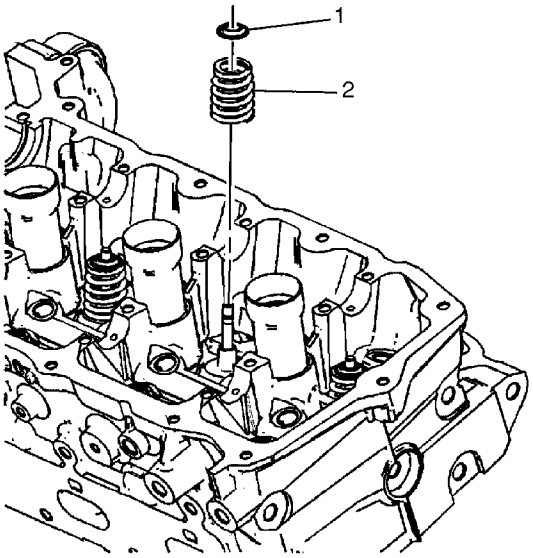
Caution: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

2. Compress the valve spring using the *J 8062* compressor and the *EN 46119* adapter .

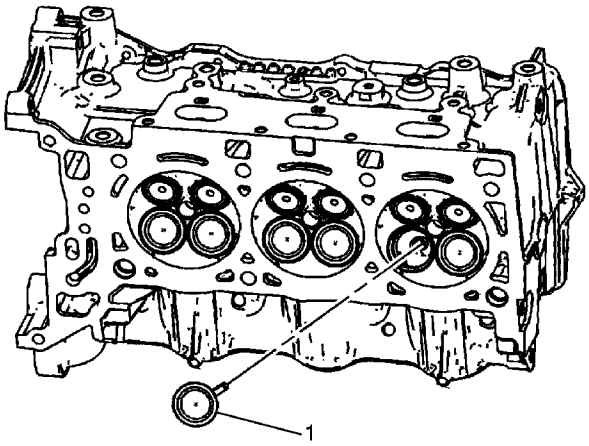


3. Use the magnet of the *EN 46117* remover/installer in order to remove the valve collets.

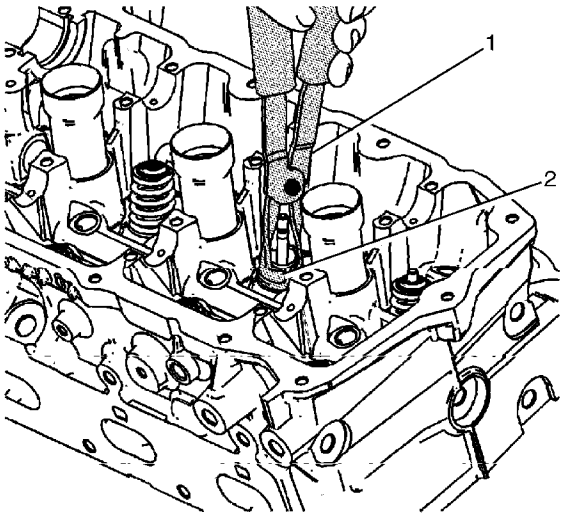
4. Remove the valve spring compressor and the adapter.



5. Remove the valve spring retainer (1).
6. Remove the valve spring (2).



7. Remove the valve (1).

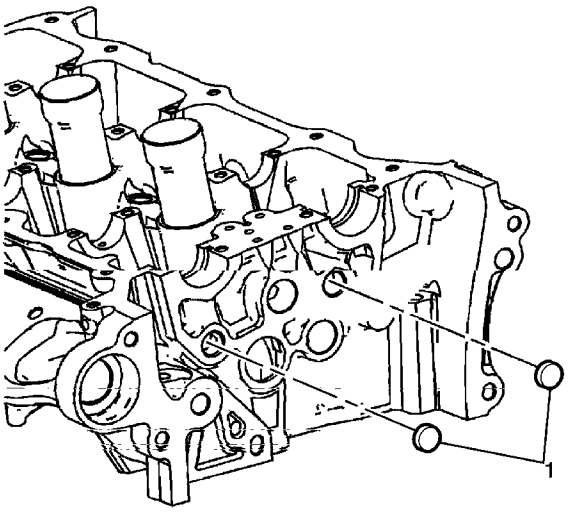


Note: NEVER reuse a valve stem oil seal.

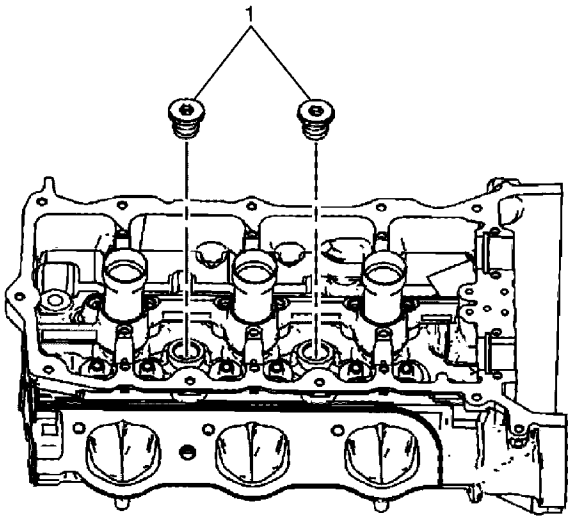
8. Remove the valve stem oil seal (2) using the *EN 46116* remover/installer (1).

   Discard the valve stem oil seals.

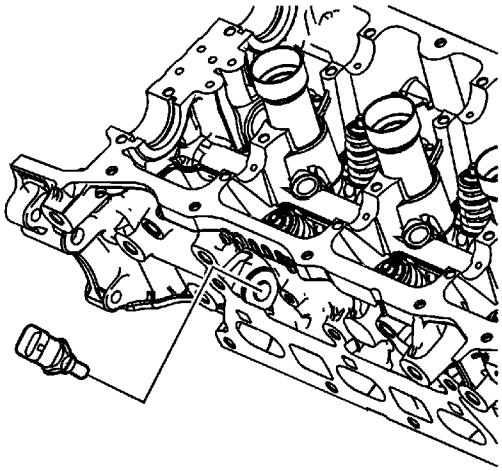
9. Repeat these procedures for the remaining valves.



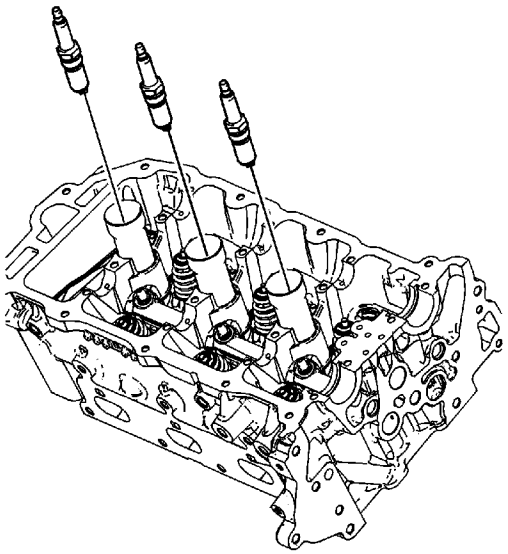
10. Remove the cylinder head oil gallery expansion plugs (1).



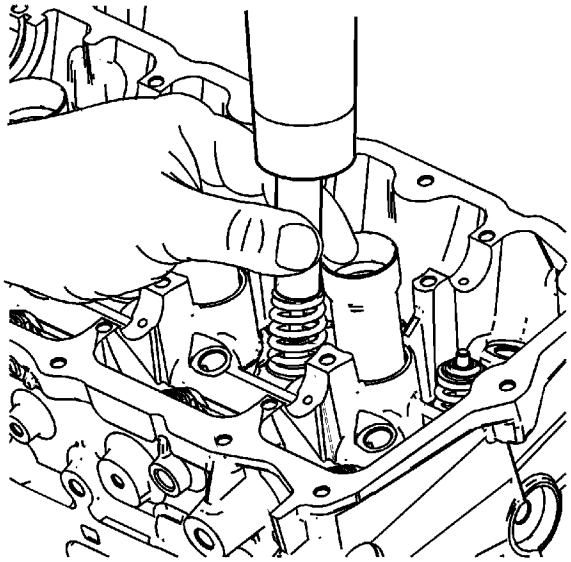
11. Remove the cylinder head coolant threaded plugs (1).



12. Remove the engine coolant temperature (ECT) sensor.

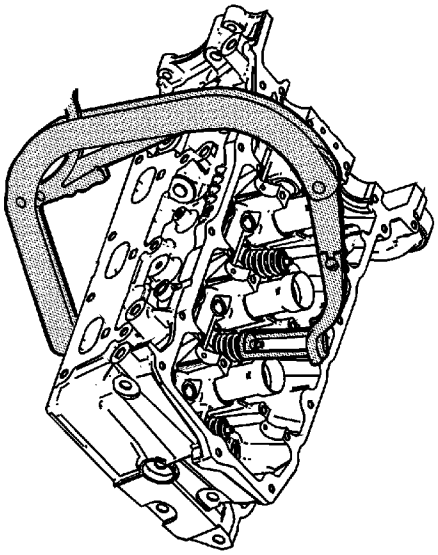


13. Remove the spark plugs.



Note: Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

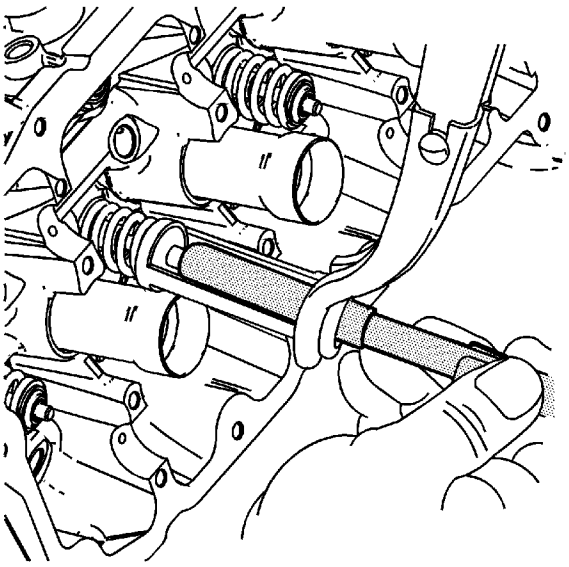
14. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.



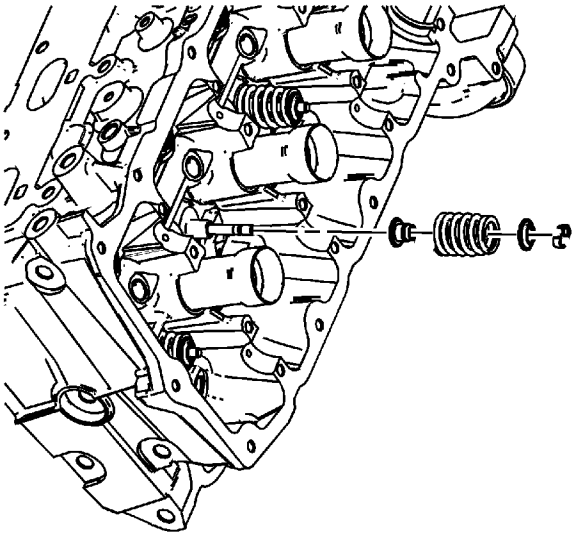
Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

Caution: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

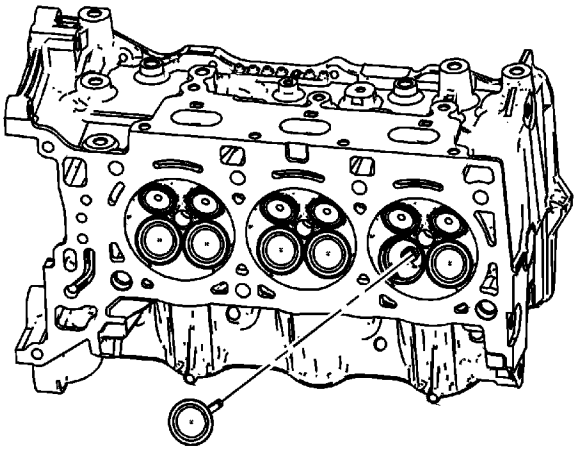
15. Compress the valve spring using the *J-8062* compressor - head off and the *EN-46119* adapter .



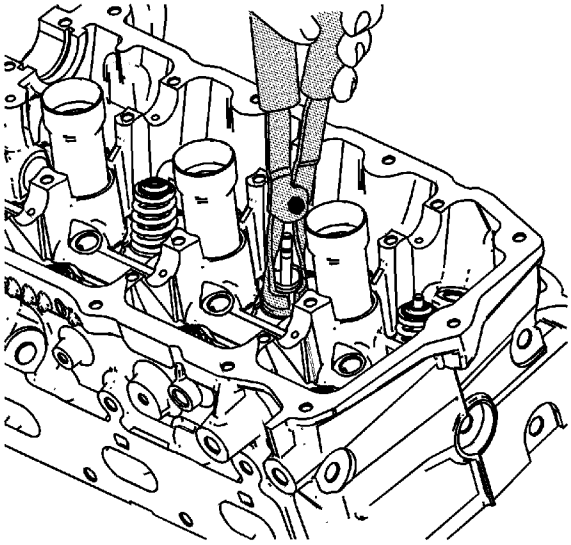
16. Use the magnet of the *EN-46117* key remover/installer in order to remove the valve keepers.
17. Remove the valve spring compressor and the adapter.



18. Remove the valve spring retainer.
19. Remove the valve spring.

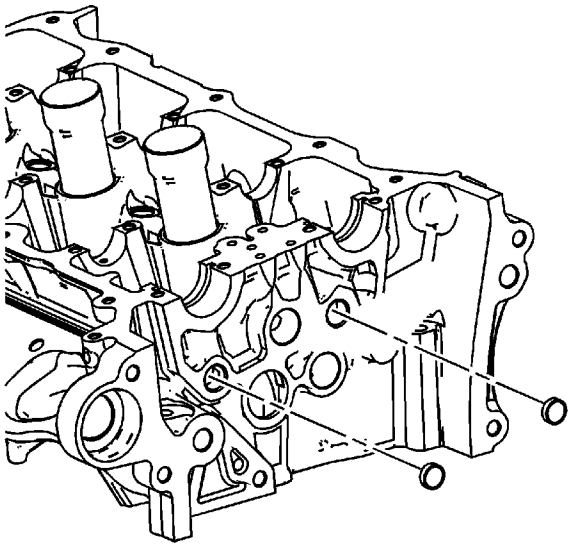


20. Remove the valve.

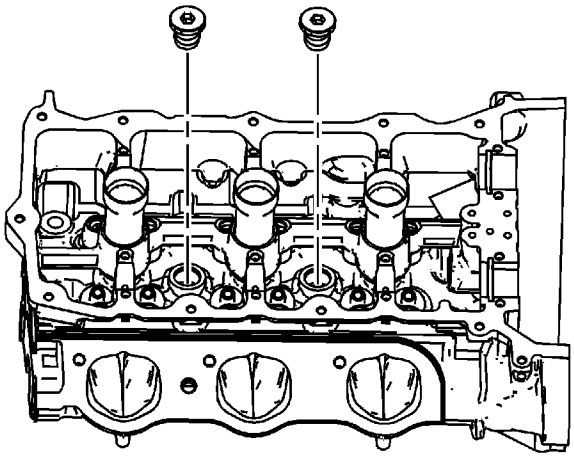


Note: NEVER reuse a valve stem oil seal.

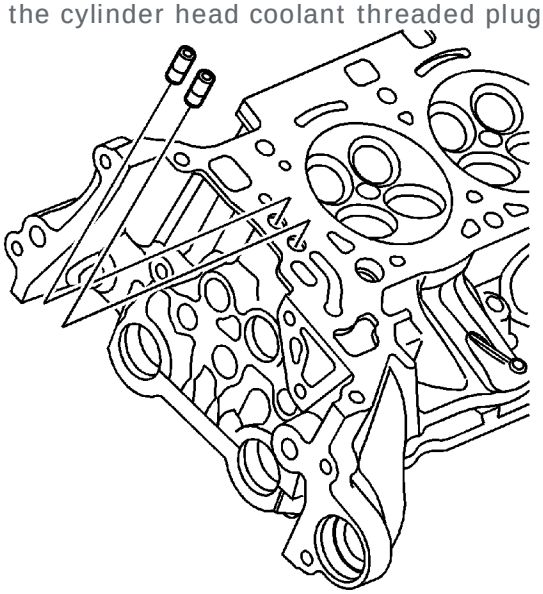
21. Remove the valve stem oil seal using the *EN-46116* seal remover/installer and discard.
22. Repeat these procedures for the remaining valves.



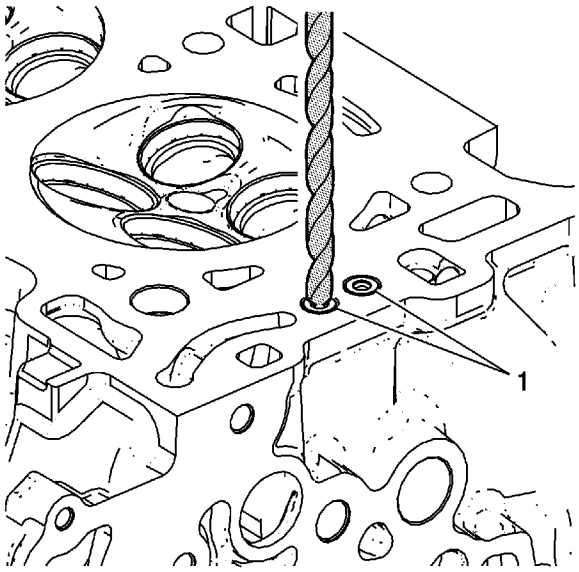
23. Remove the cylinder head oil gallery expansion plugs.



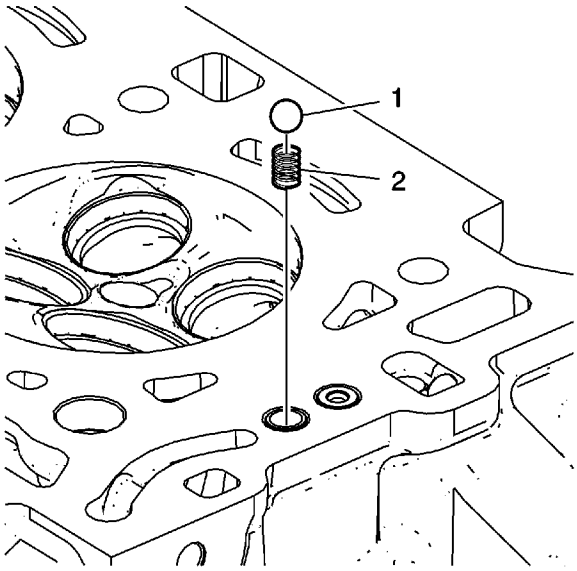
24. Remove the cylinder head coolant threaded plugs.



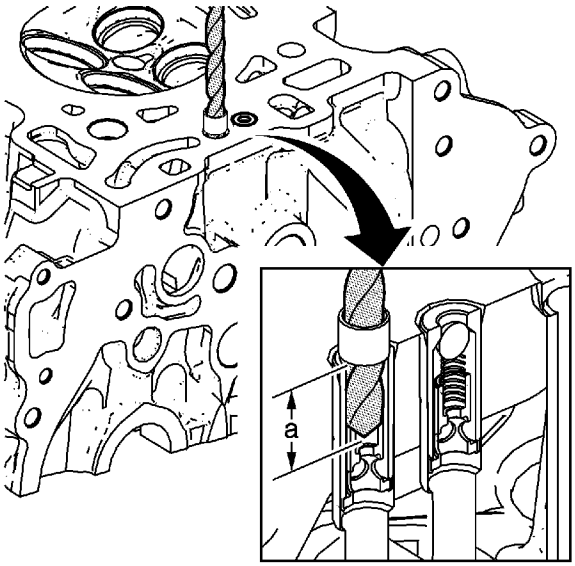
25. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced.



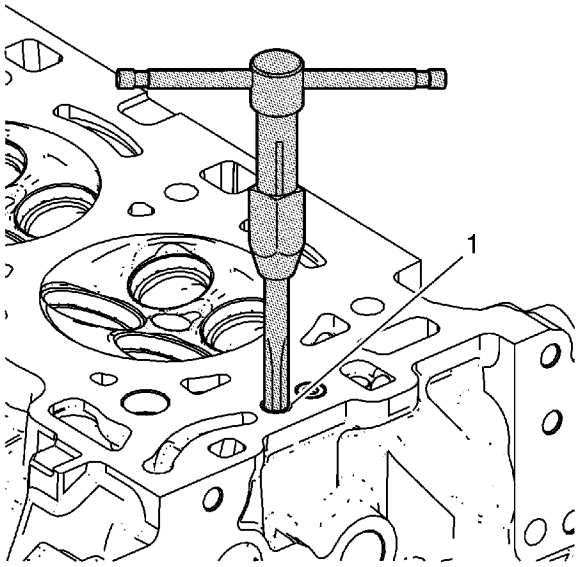
26. Place cylinder head on firm surface with check valves (1) facing up. Protect all cylinder head components and machined surfaces.
27. Using drill bit EN-46122-3, drill out top portion of check valve to expose internal check ball.



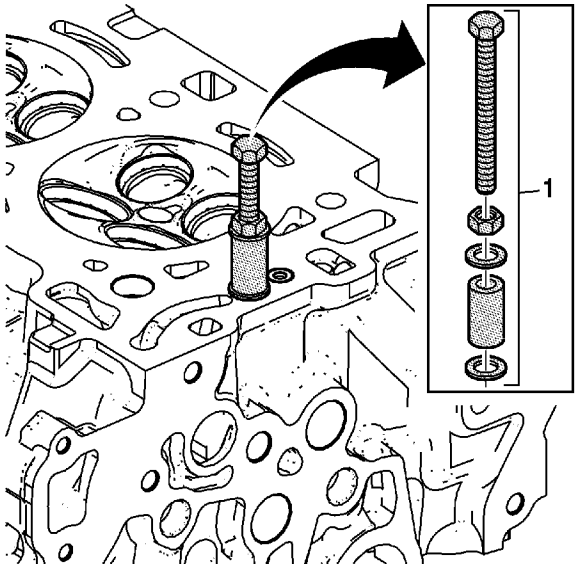
28. Remove check ball (1) and check ball spring (2) from inside of check valve.



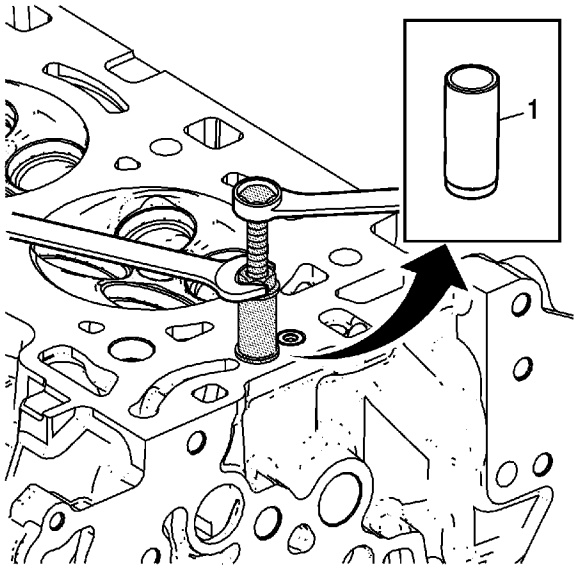
29. Continue drilling remainder of check valve sleeve to a depth of approximately 19 mm (0.75 in) (a) by placing tape on drill bit as a depth gauge. It is not necessary or desirable to drill completely through the bottom of the check valve.



30. Lubricate tap EN-46122-4 with lubricant included in *EN-46122* remover/installer . Tap drilled out portion of check valve (1) remaining in cylinder head. Tap to full depth possible until tap bottoms out in head.



31. Assemble bolt, nut, washers, and collar EN-46122-2 (1) as shown. Position collar with slightly-larger inside diameter DOWN toward the cylinder head.
32. Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer.



33. Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve (1) is removed from the cylinder head.
34. Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.

Cylinder Head Cleaning and Inspection

Special Tools

- *J 8001* Dial Indicator Set
- *J 8358* Carbon Removal Brush
- *J 28410* Gasket Remover
- *J 42096* Valve Guide Reamer

For equivalent regional tools, refer to Special Tools.

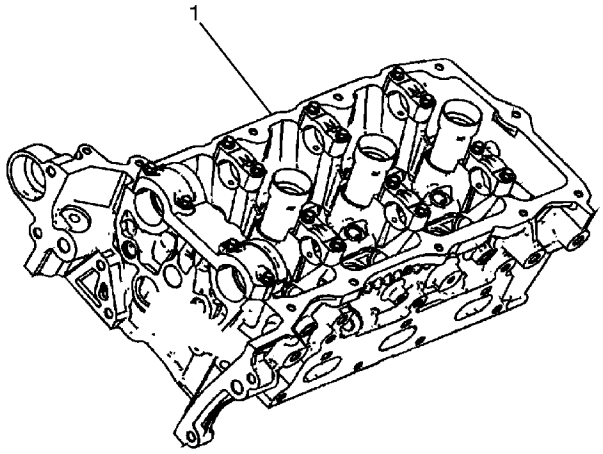
Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using *J 28410* remover .
2. Clean all cylinder head surfaces with non-corrosive solvent.

Warning: Refer to Safety Glasses Warning in the Preface section.

3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chambers using the *J 8358* brush .
5. Clean any debris or build-up from the lifter pockets.

Visual Inspection

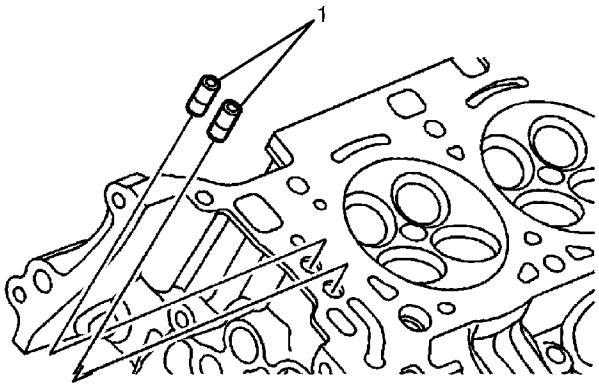


1. Inspect the cylinder head (1) camshaft bearing surfaces for the following conditions:
   - Scoring or pitting above acceptable tolerances

© 2010 General Motors Corporation. All rights reserved.

- Discoloration from overheating
- Deformation from wear above acceptable tolerances
- If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.

2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
3. Inspect the cylinder head for the following:
   - Cracks, damage or pitting in the combustion chambers
   - Debris in the oil galleries -- Continue to clean the galleries until all debris is removed.
   - Coolant leaks or damage to the deck face sealing surface -- If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement - Deck Flatness Inspection.
   - Burrs or any defects that may degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
   - Damage to any gasket surfaces
   - Damage to any threaded bolt holes
   - Burnt or eroded areas in the combustion chamber
   - Cracks in the exhaust ports and combustion chambers
   - External cracks in the water passages
   - Restrictions in the intake or exhaust passages
   - Restrictions in the cooling system passages
   - Rusted, damaged or leaking core plugs
4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.



5. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. Refer to Cylinder Head Disassemble.

Cylinder Head Measurement

Camshaft Journal Clearance

1. Install the camshaft bearing cap in the cylinder head without the camshaft.

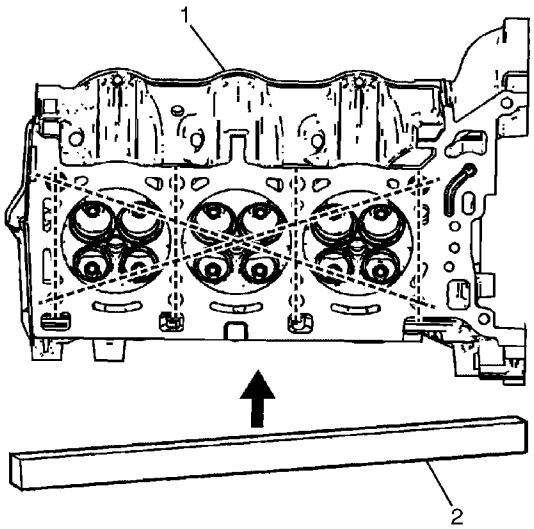
   Caution: Refer to Fastener Caution in the Preface section.

2. Install the camshaft cap bolts and tighten to **10 N·m (89 lb in)**.
3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that may inhibit correct camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to **10 N·m (89 lb in)**.
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

Deck Flatness Inspection

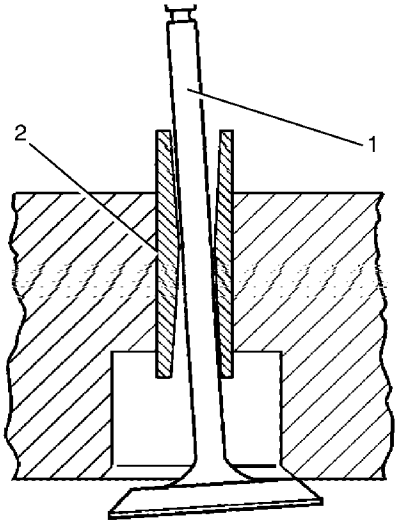


1. Ensure the cylinder head (1) decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that may inhibit correct cylinder head gasket sealing.
3. Place a straight-edge (2) diagonally across the cylinder head (1) deck face surface.
4. Measure the clearance between the straight-edge (2) and the cylinder head (1) deck face using a feeler gage at 4 points along the straight-edge (2).
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head (1) deck surface does not

require resurfacing.

6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that may inhibit correct cylinder head gasket sealing are present, the cylinder head (1) deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head (1) deck surface requires more than 0.25 mm (0.010 in) material removal the cylinder head (1) must be replaced.

Valve Guide Measurement



1. Measure the valve stem (1)-to-guide (2) clearance. Valve stem-to-guide clearance above acceptable tolerances may cause oil consumption above acceptable tolerances and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the *J 8001* indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem (1) from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem (1) just above the valve guide (2).
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem (1) from side to side in order to obtain a clearance reading. Refer to Engine Mechanical Specifications.
   - If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the *J 42096* reamer . There is 1 size of oversized valve stem available for service.
   - Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
   - If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

Valve Spring Inspection and Measurement

Special Tools

J 22738-B Valve Spring Tester

For equivalent regional tools, refer to Special Tools.

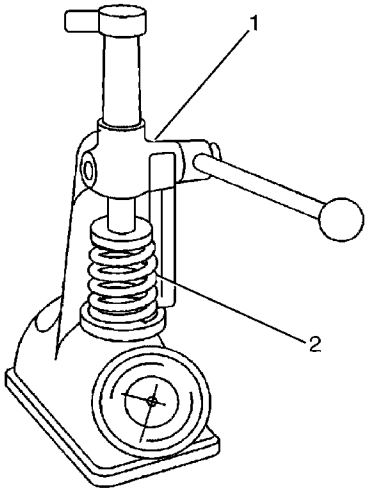
Inspection Procedure

1. Clean the valve springs in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

Measurement Procedure



1. Measure the valve spring tension using the *J 22738-B* tester . Refer to Engine Mechanical Specifications.
2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

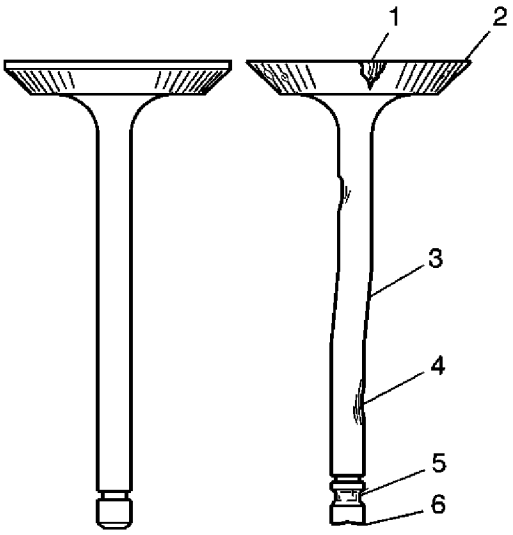
© 2010 General Motors Corporation. All rights reserved.

Valve and Seat Grinding

Valve Cleaning Procedure

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

Valve Visual Inspection Procedure



1. Inspect the valve for damage from the head to tip for the following conditions:
   - Pitting in the valve seat area (1)
   - Lack of valve margin (2)
   - Bending in the valve stem (3)
   - Pitting or excessive wear in the stem (4)
   - Worn valve key grooves (5)
   - Worn valve tip (6)
2. Replace the valve if any of these conditions exist.

Valve Measurement and Reconditioning Overview

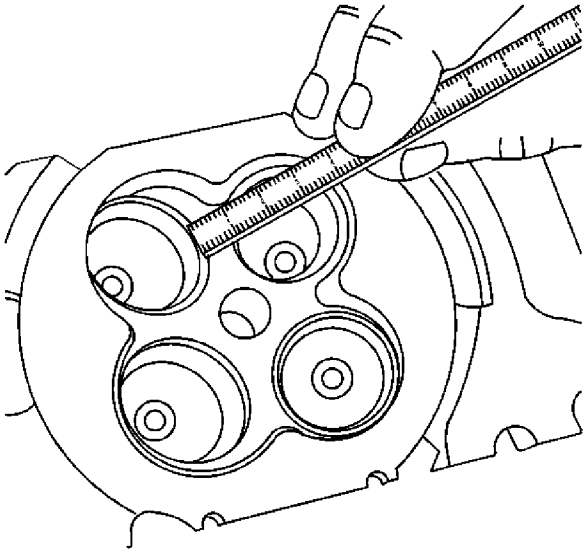
Note:

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it

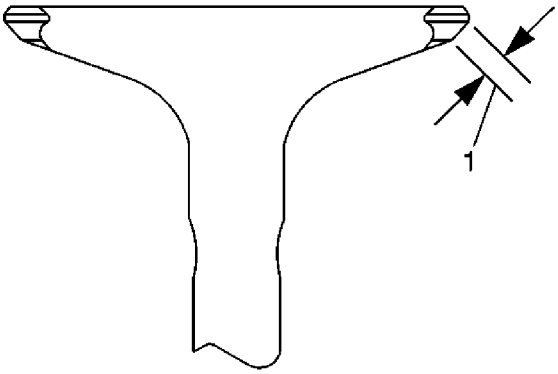
© 2010 General Motors Corporation. All rights reserved.

is critical to perform the measurement procedures after reconditioning.

Valve Seat Width Measurement Procedure



1. Measure the valve seat width in the cylinder head using a proper scale.



2. Measure the seat width on the valve face (1) using a proper scale.

Note: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter (margin) of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in Engine Mechanical Specifications.
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

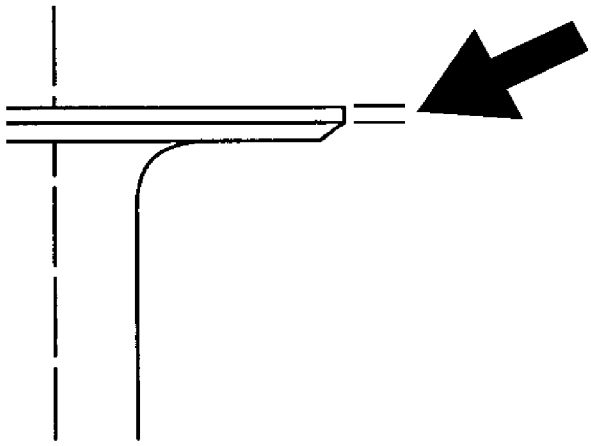
Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

   Caution: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in Engine Mechanical Specifications.
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Margin Measurement Procedure

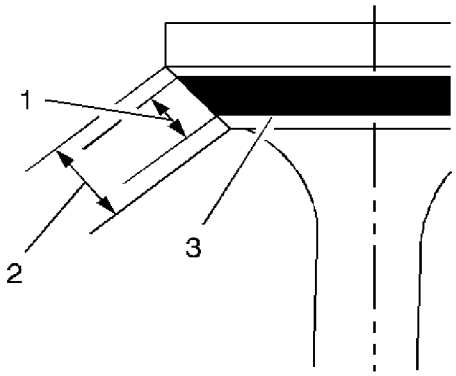


1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification and do not require refacing, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve-to-Seat Concentricity Measurement Procedure

Note:

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.

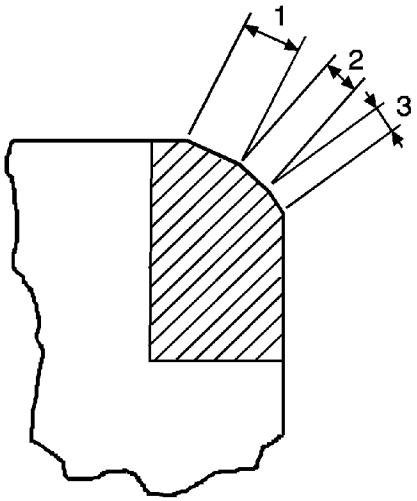


1. Coat the valve face lightly with blue dye (3).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
   - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark will be made around the entire face (1).

     Note: The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

   - If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure



Note:

- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

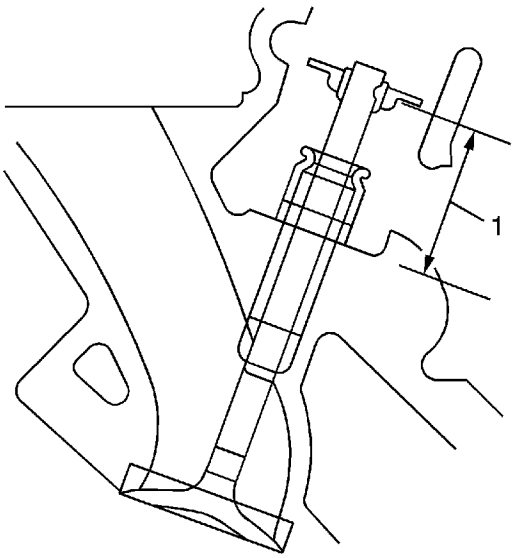
1. Grind the valve seats (2) to the proper angle specification listed in Engine Mechanical Specifications.
2. Using the proper angle specification listed in Engine Mechanical Specifications , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in Engine Mechanical Specifications , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in Engine Mechanical Specifications.
4. If the original valve is being used, grind the valve to the specifications listed in Engine Mechanical Specifications. Measure the valve margin again after grinding using the Valve Margin Measurement Procedure. Replace the valve if the margin is out of specification. New valves do not require grinding.
5. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
6. Install the valve in the cylinder head.
   - If you are using refaced valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.

     Note: Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.

   - If you are using new valves, do not lap the valves under any condition.
7. After obtaining the proper valve seat width in the cylinder head, you must re-measure the

valve stem height using the Valve Stem Height Measurement Procedure.
8. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure



Note: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve into the valve guide.
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to Engine Mechanical Specifications.
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

Caution: DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.

Caution: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.

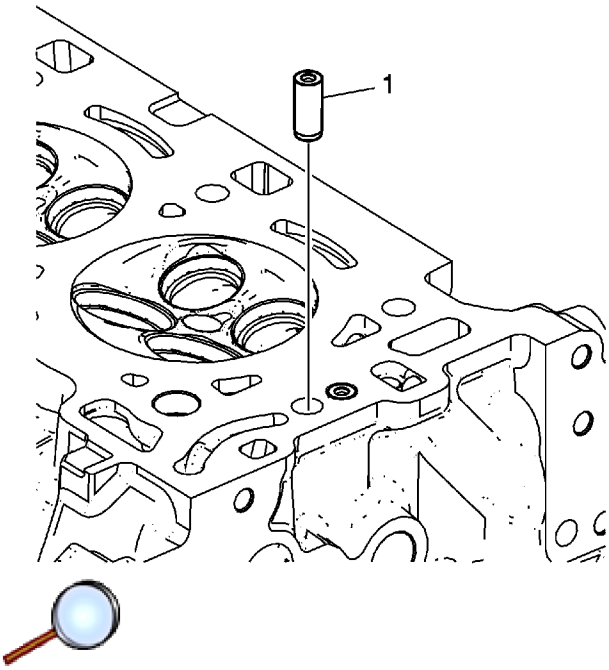
7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

Cylinder Head Assemble

Special Tools

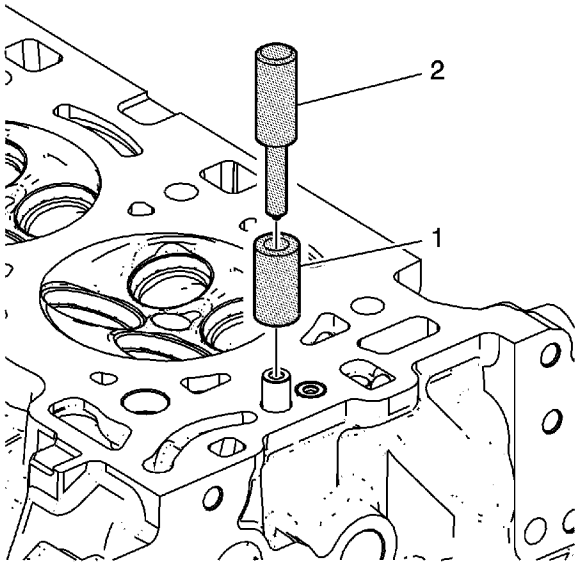
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Stem Key Remover/Installer
- *EN 46119* Off-Vehicle Valve Spring Compressor Adapter
- *EN-46122* Camshaft Position Actuator Check-Ball Valve Remover/Installer
- *J 8062* Valve Spring Compressor - Head Off

For equivalent regional tools, refer to Special Tools.

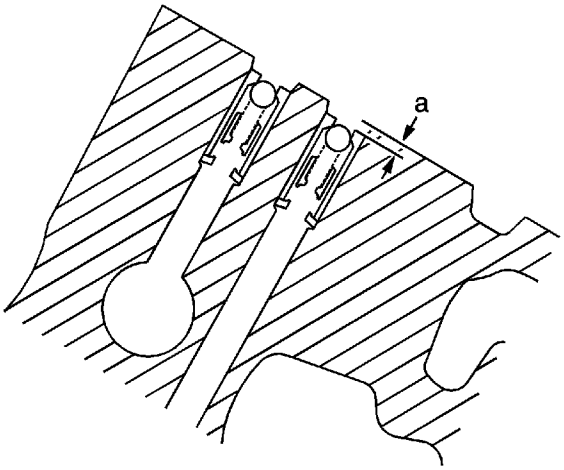


1. Use lubricant included with *EN-46122* remover/installer to lubricate outside of new check valve (1).
2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.

© 2010 General Motors Corporation. All rights reserved.

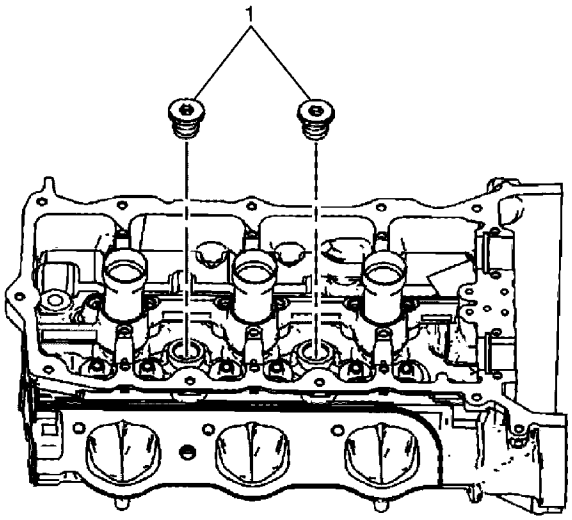


3. Place collar EN-46122-2 (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.
4. Using the driver EN-46122-1 (2), lightly tap the new check valve into place until the driver stops against the top of the collar.

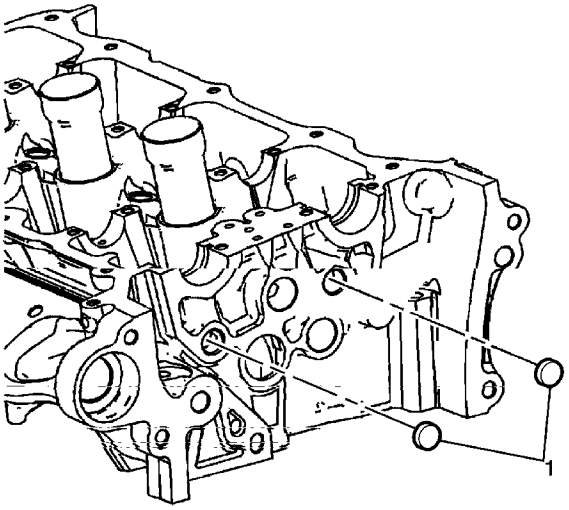


5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to 2 mm (0.0787 in) below the cylinder head deck surface (a).

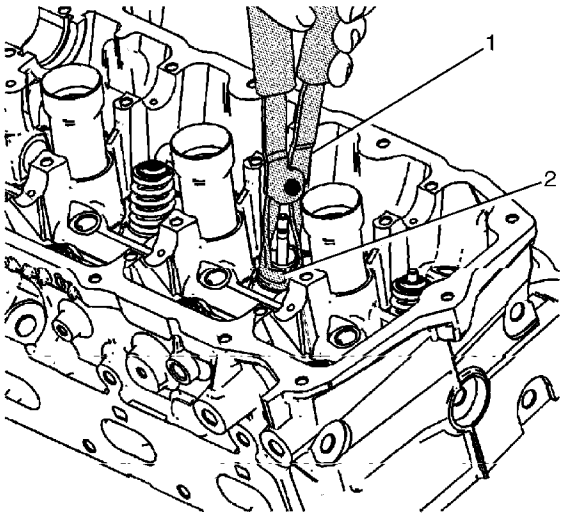
Caution: Refer to Fastener Caution in the Preface section.



6. Install the cylinder head coolant threaded plugs (1) and tighten to **45 N·m (33 lb ft)**.



7. Install the NEW cylinder head oil gallery expansion plugs (1).



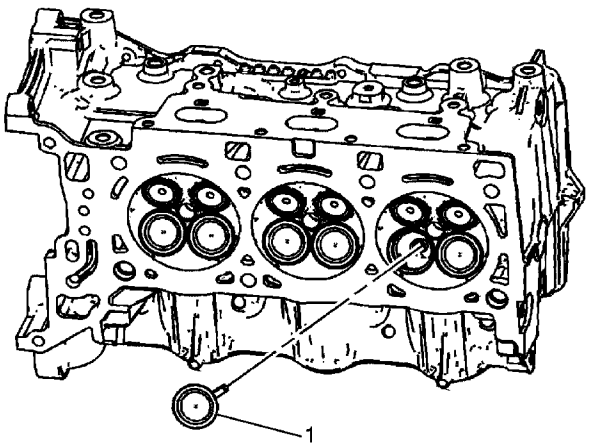
8. Place the valve stem oil seals (2) onto the guides.

Note: NEVER reuse a valve stem oil seal (2). Always use new seals when assembling the cylinder head.

9. Mount a new valve stem oil seal (2) using the *EN 46116* remover/installer (1).

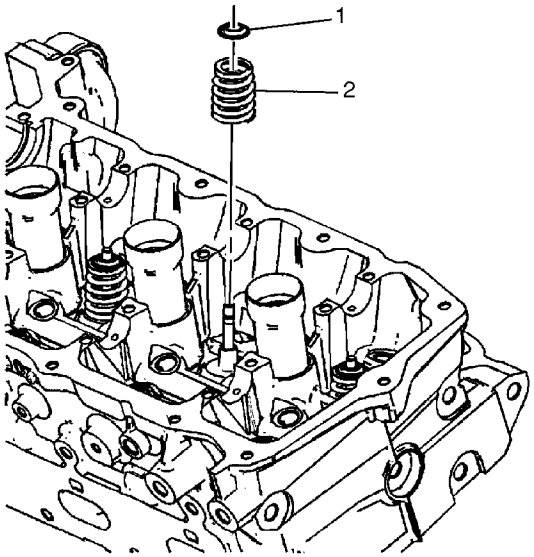
Note: Force should only be applied to the valve spring contact area of the new valve stem oil seal (2) during installation.

10. Push and twist the valve stem oil seal (2) into position on the valve guide until the seal positively locks on the guide using the *EN 46116* remover/installer (1).
11. Lubricate the valve stem and valve guide ID with clean engine oil.

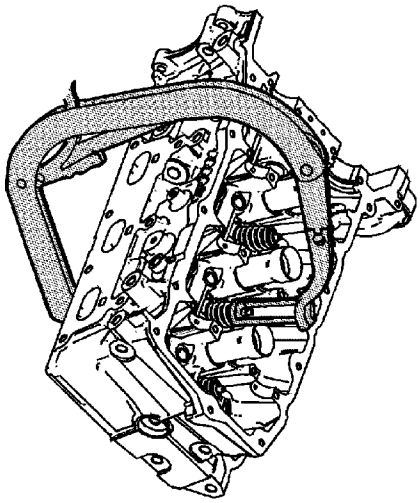


Note: The valve stem oil seal must not come loose from the valve guide when the valve is installed.

12. Insert the valve (1) into the valve guide until it bottoms on the valve seat.



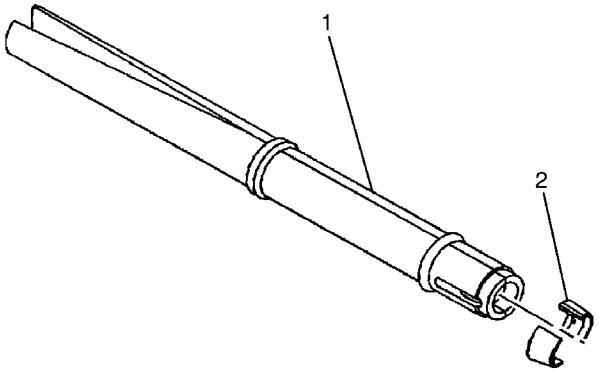
13. Install the valve spring (2).
14. Place the valve spring retainer (1) onto the valve spring (2).



Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

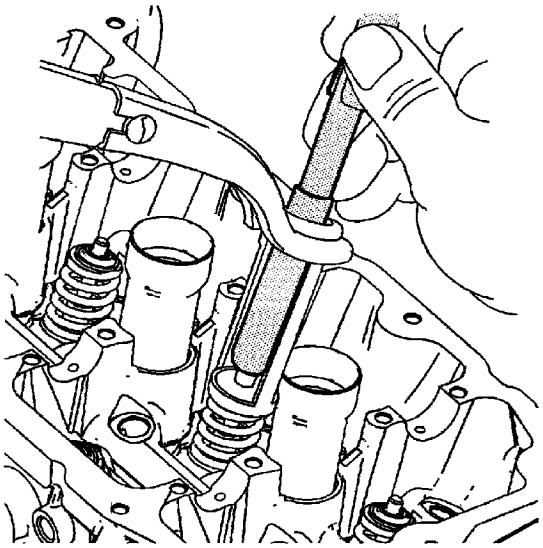
Caution: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

15. Compress the valve spring using the *J 8062* compressor and the *EN 46119* adapter .



Note: Ensure correct directional placement of valve collets (2) in the *EN 46117* remover/installer (1). The valve collets (2) must be installed with the tapered end towards the valve stem seal.

16. With the spring compressed, install the valve collets (2) into the *EN 46117* remover/installer (1).



17. Place the valve collets into position by pushing the *EN 46117* remover/installer downward

and releasing tension on the *EN 46119* adapter and the *J 8062* compressor .

18. Verify that the valve collets are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.

Camshaft Cleaning and Inspection

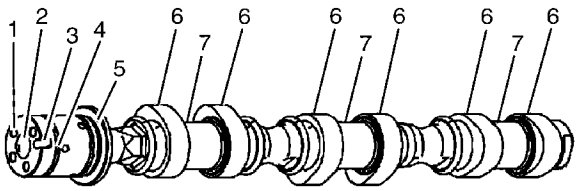
Cleaning Procedure

1. Clean the camshaft in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the camshaft with compressed air.

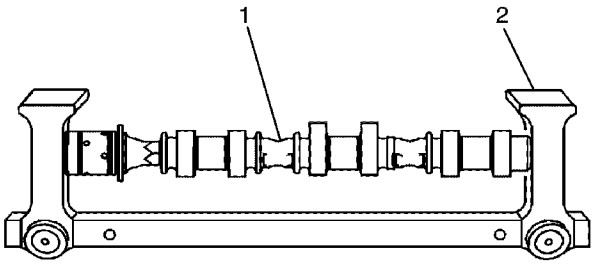
Visual Inspection



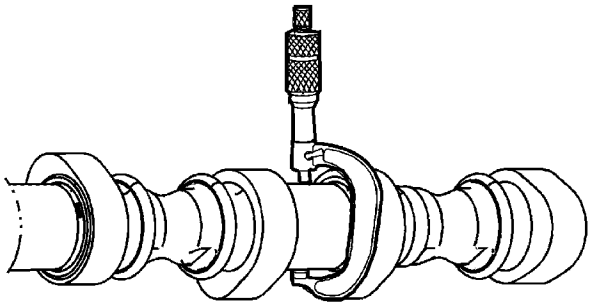
1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.
2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
   - Scoring or pitting above acceptable tolerances
   - Discoloration from overheating
   - Deformation from wear above acceptable tolerances, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

Camshaft Measurement

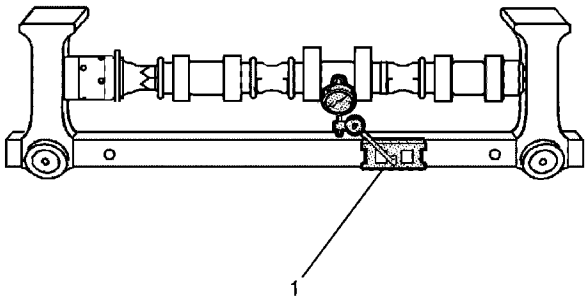
© 2010 General Motors Corporation. All rights reserved.



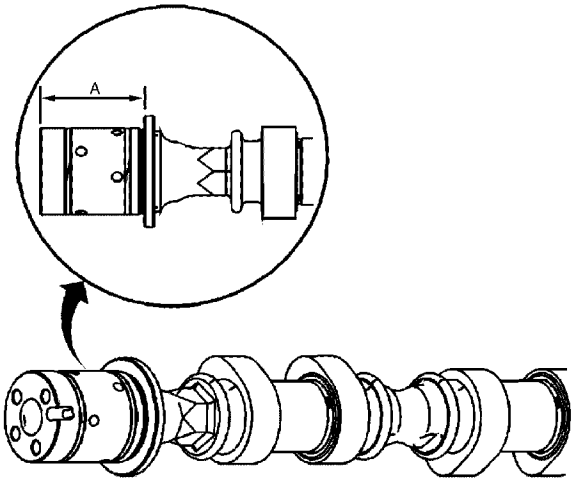
1. With the camshaft (1) in a suitable fixture (2), measure the camshaft (1) for wear.



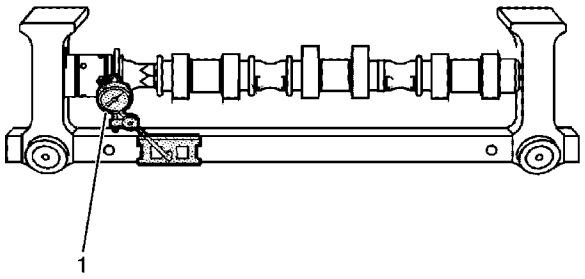
2. Measure and record the camshaft journals (2) for diameter and out-of-round using an outside micrometer (1). Refer to Engine Mechanical Specifications.
   - If the diameter is smaller than specifications, replace the camshaft.
   - If the out-of-round exceeds specifications, replace the camshaft.



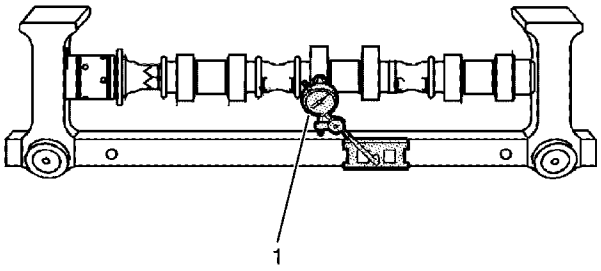
3. Measure and record the camshaft runout using a dial indicator (1). Refer to Engine Mechanical Specifications.



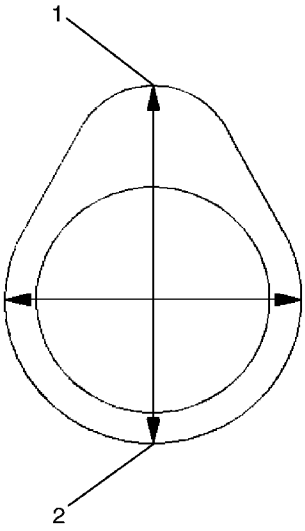
4. Measure the camshaft thrust width (A) for wear using a depth micrometer. Refer to Engine Mechanical Specifications.



5. Measure the camshaft thrust wall surface for runout using a dial indicator (1). Refer to Engine Mechanical Specifications.
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.



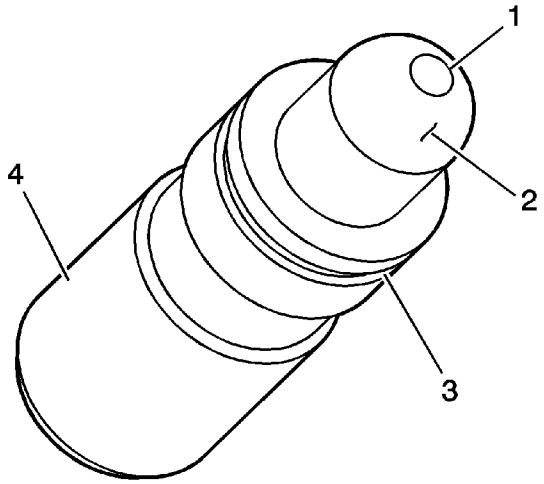
7. Measure the camshaft lobes for wear using a dial indicator (1).



8. Place the dial indicator with the indicator tip on the base circle (2) of the camshaft lobe.
   8.1. Place the dial indicator at zero.
   8.2. Rotate the camshaft until the indicator tip is at the highest point (1) on the lobe. This reading is the lift of the camshaft lobe. Refer to Engine Mechanical Specifications.
   8.3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

Valve Lifters Cleaning and Inspection

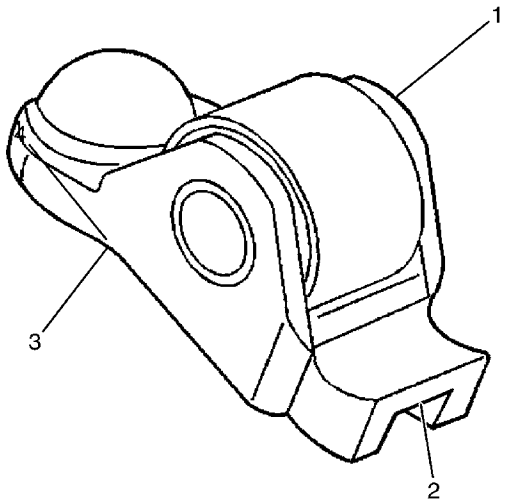
Caution: Refer to Valve Lifter Priming Caution in the Preface section.



1. Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas:
   - A plugged oil passage (1)
   - A scored or worn camshaft follower pivot area (2)
   - A damaged or broken retainer (3), some applications
   - A severely scuffed or worn SHLA body (4)
2. Replace the SHLA or SHLAs as necessary.

© 2010 General Motors Corporation. All rights reserved.

Valve Rocker Arm Cleaning and Inspection



1. Inspect the valve rocker arm (1) for the following:
   - Flat spots.
   - Scoring and pitting above acceptable tolerances.
   - Ensure the roller spins freely.
2. Inspect the valve rocker arm valve tip area (2).
3. Inspect the valve rocker arm Stationary Hydraulic Lash Adjuster (SHLA) pivot area (3).
4. Replace the valve rocker arm or valve rocker arms as necessary.

© 2010 General Motors Corporation. All rights reserved.

Camshaft Timing Drive Components Cleaning and Inspection

Cleaning Procedure

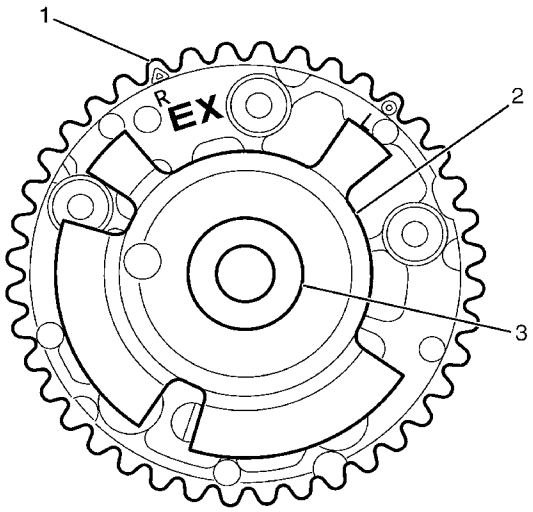
1. Clean all the following components with solvent:
   - Crankshaft sprocket.
   - Primary timing drive chain.
   - Primary timing drive chain shoe.
   - Primary timing drive chain guides.
   - Primary timing drive chain tensioner.
   - Secondary timing drive chains.
   - Secondary timing drive chain shoes.
   - Secondary timing drive chain guides.
   - Secondary timing drive chain tensioners.
   - Timing component fastening bolts.
2. Clean each camshaft position actuator's exterior with solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

3. Dry the timing components with compressed air.

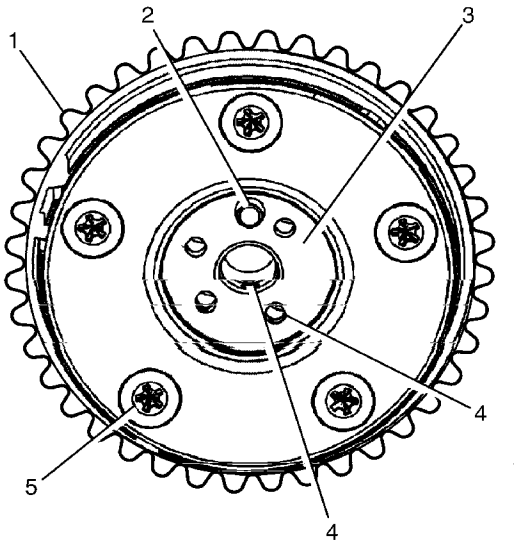
Visual Inspection

Camshaft Position Actuators (LY7 Engine)

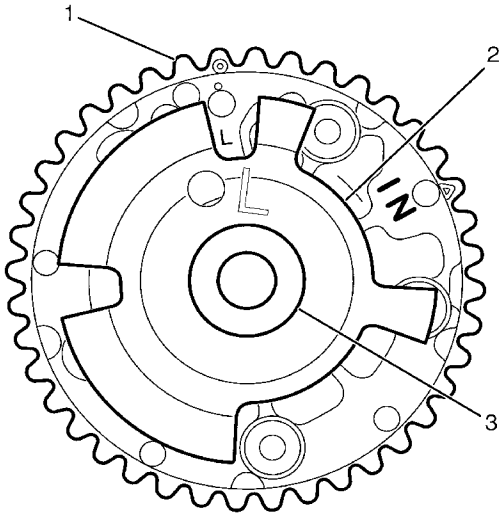


© 2010 General Motors Corporation. All rights reserved.

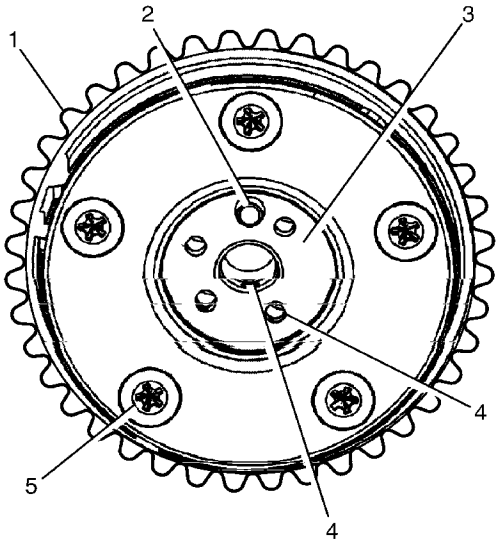
1. Inspect the front of the exhaust camshaft position actuators for the following:
   - Sprocket damage (1).
   - Reluctor/sensor wheel damage (2).
   - Camshaft position actuator to camshaft retaining bolt seating/sealing inner hub flange damage (3).



2. Inspect the back of the exhaust camshaft position actuators for the following:
   - Sprocket damage (1).
   - Camshaft locating pin damage (2).
   - Camshaft seating/sealing inner hub flange damage (3).
   - Blockage to the oil passages (4).
   - Loose or missing housing bolts (5).



3. Inspect the front of the intake camshaft position actuators for the following:
   - Sprocket damage (1).
   - Reluctor/sensor wheel damage (2).
   - Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3).

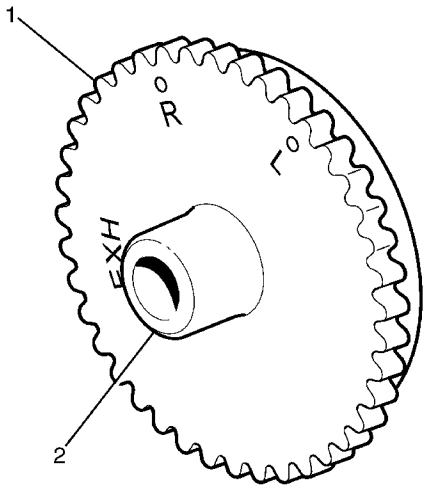


4. Inspect the back of the intake camshaft position actuators for the following:
   - Sprocket damage (1).
   - Camshaft locating pin damage (2).
   - Camshaft seating/sealing inner hub flange damage (3).
   - Blockage to the oil passages (4).

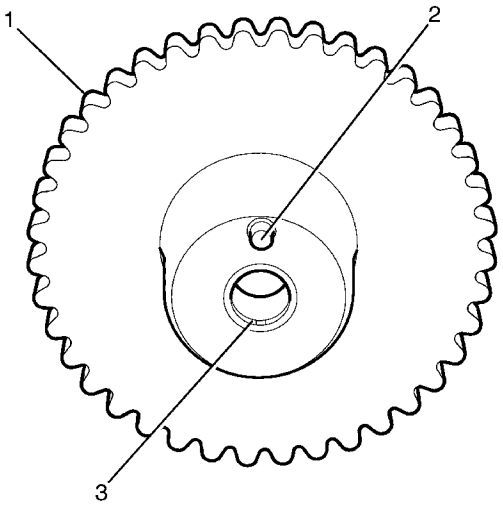
- Loose or missing housing bolts (5).

5. Replace a damaged camshaft position actuator.

Camshaft Position Actuators and Sprockets (LE0 & LW2 Engines)

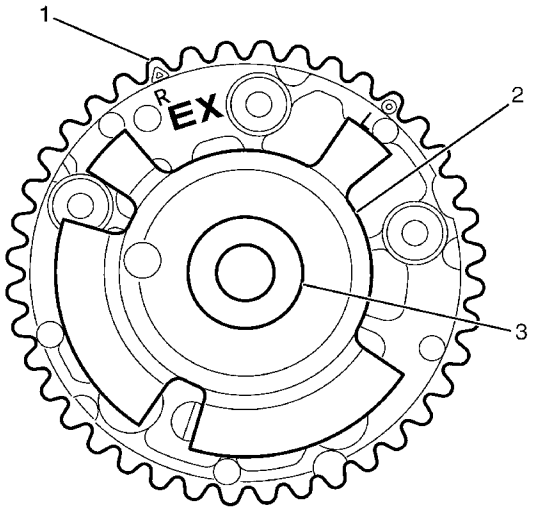


1. Inspect the front of the exhaust camshaft sprockets for the following:
   - Sprocket damage (1).
   - Exhaust camshaft sprocket bolt seating inner hub damage (2).

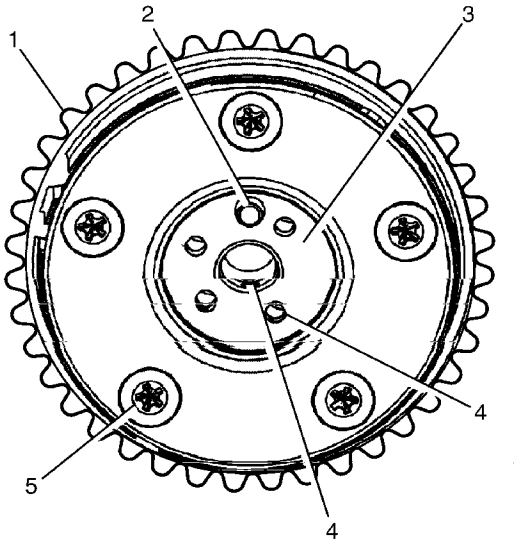


2. Inspect the back of the exhaust camshaft sprockets for the following:
   - Sprocket damage (1).

- Camshaft locating pin damage (2).
- Camshaft seating/ sealing inner hub flange damage (3).



3. Inspect the front of the intake camshaft position actuators for the following:
   - Sprocket damage (1).
   - Reluctor/sensor wheel damage (2).
   - Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3).

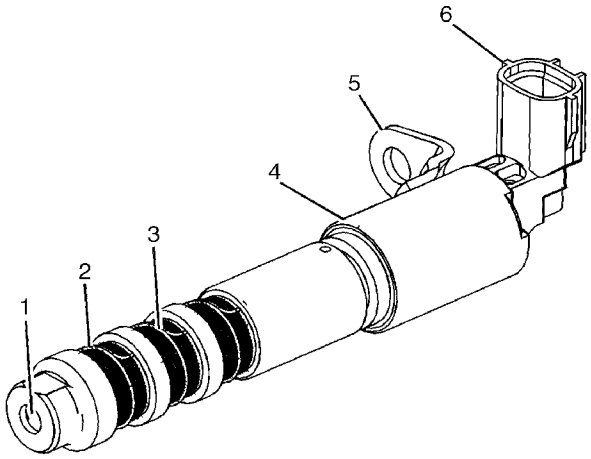


4. Inspect the back of the intake camshaft position actuators for the following:
   - Sprocket damage (1).

- Camshaft locating pin damage (2).
- Camshaft seating/sealing inner hub flange damage (3).
- Blockage to the oil passages (4).
- Loose or missing housing bolts (5).

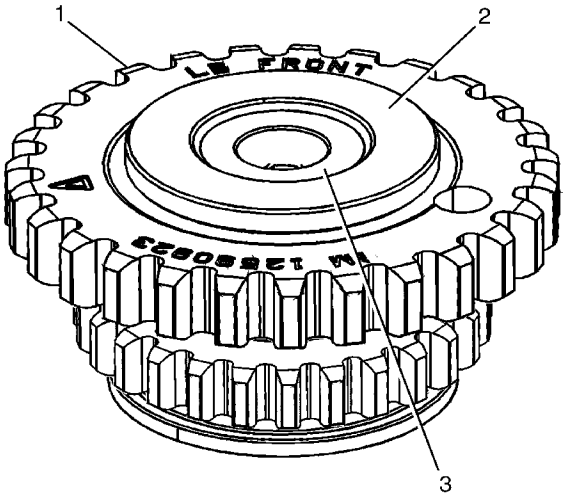
5. Replace a damaged camshaft position actuator.

Camshaft Position Actuator Solenoids

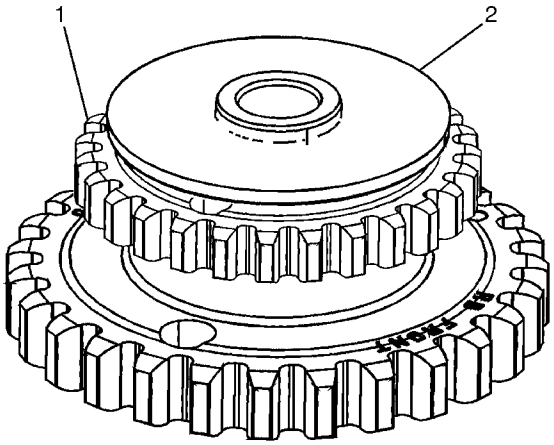


1. Inspect the camshaft position actuator solenoids for the following:
   - Blockage to the oil passage (1).
   - Missing or damaged oil screen clip (2).
   - Blockage or damage to the oil screen (3).
   - Damage to the sealing surface for the camshaft position actuator solenoid oil seal (4).
   - Damage to the bracket (5).
   - Damage to the wiring harness connection and/or terminals (6).
2. Replace a damaged camshaft position actuator solenoid.

Left Intermediate Sprocket

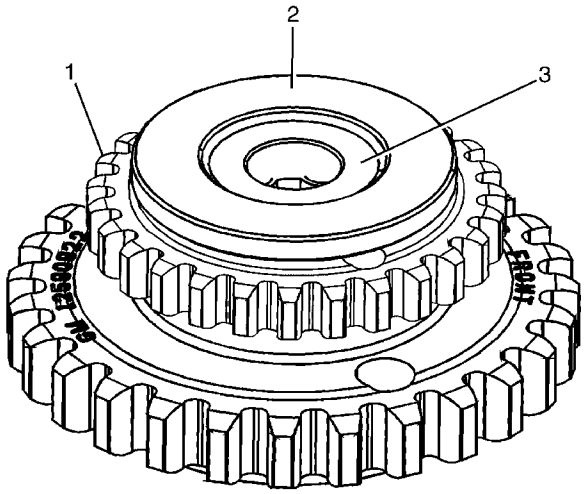


1. Inspect the front of the left intermediate sprocket for the following:
   - Damage to the primary camshaft drive chain sprocket (1).
   - Damage to the hub bearing (2) -- Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
   - Damage to the bolt flange seating/sealing surface (3).

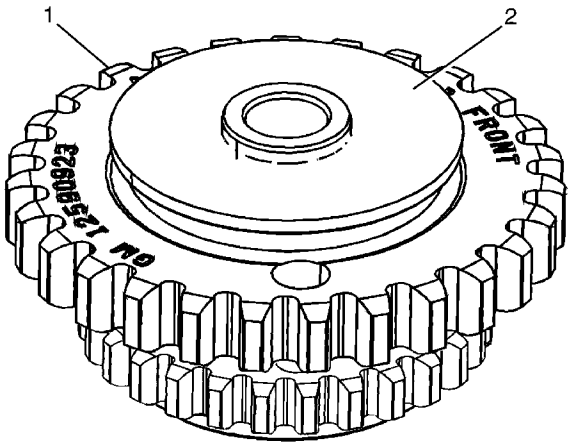


2. Inspect the back of the intermediate sprocket for the following:
   - Damage to the left secondary camshaft drive chain sprocket (1).
   - Damage to the bearing hub-to-engine block sealing surface (2).
3. Replace a damaged left intermediate sprocket.

Right Intermediate Sprocket



1. Inspect the front of the right intermediate sprocket for the following:
   - Damage to the right secondary camshaft drive chain sprocket (1)
   - Damage to the bearing hub bearing (2) -- Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
   - Damage to the bolt flange seating/sealing surface (3)

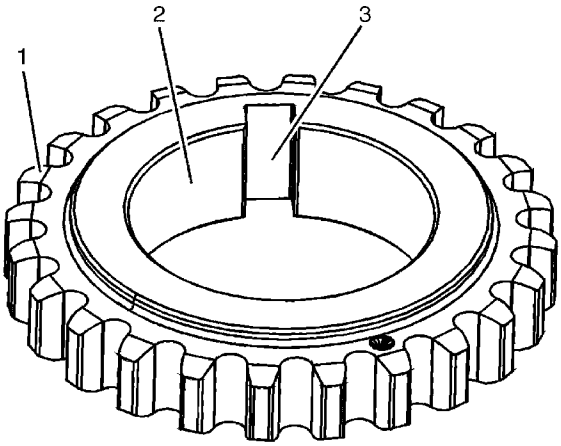


2. Inspect the back of the right intermediate sprocket for the following:
   - Damage to the primary camshaft drive chain sprocket (1)

- Damage to the bearing hub-to-engine block sealing surface (2)

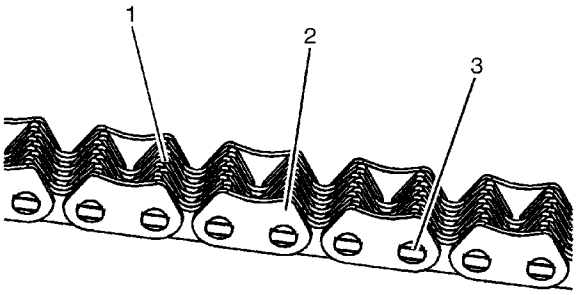
3. Replace a damaged right intermediate sprocket.

Crankshaft Sprocket



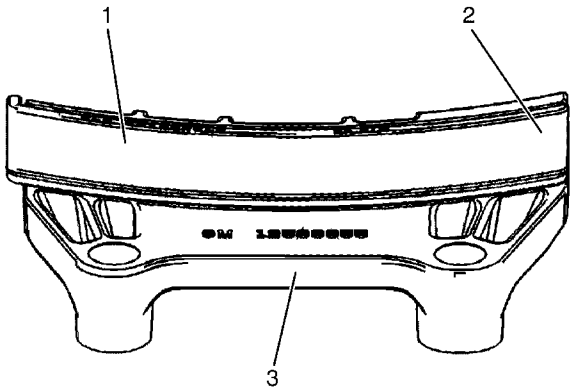
1. Inspect the crankshaft sprocket for the following:
   - Sprocket damage (1)
   - Bore damage (2)
   - Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

Primary and Secondary Timing Chains



1. Inspect the primary and secondary timing chains for the following:
   - Binding or worn links (1)
   - Loose links (2)
   - Loose pins (3)
2. Replace a damaged primary timing chain.

Primary Timing Chain Upper Guide

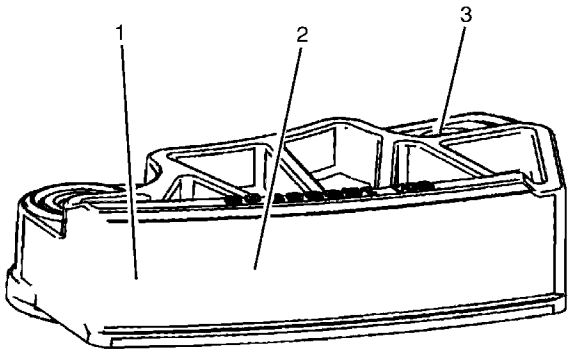


1. Inspect the primary timing chain upper guide for the following:
   - Worn guide surface (1)

- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain upper guide.

Primary Timing Chain Lower Guide

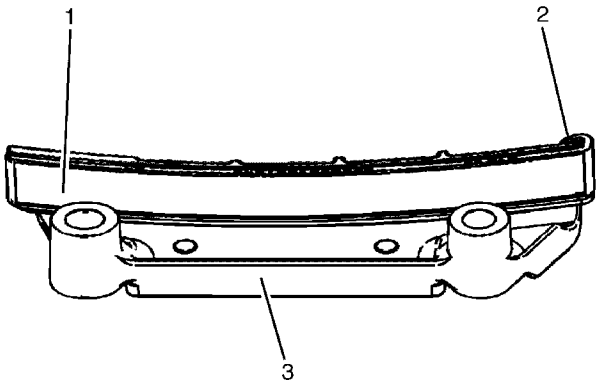


1. Inspect the primary timing chain lower guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)

   Note: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

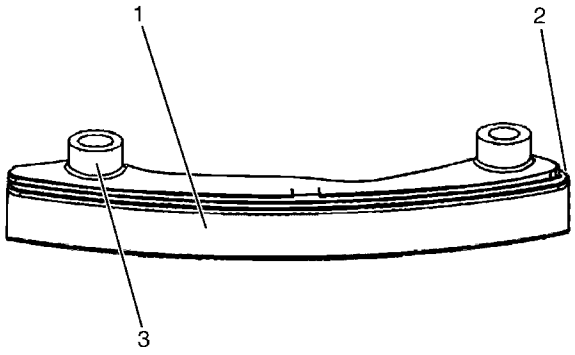
2. Replace a damaged primary timing chain lower guide by replacing the oil pump.

Left Secondary Timing Chain Guide



1. Inspect the left secondary timing chain guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)
2. Replace a damaged left secondary timing chain guide.

Right Secondary Timing Chain Guide

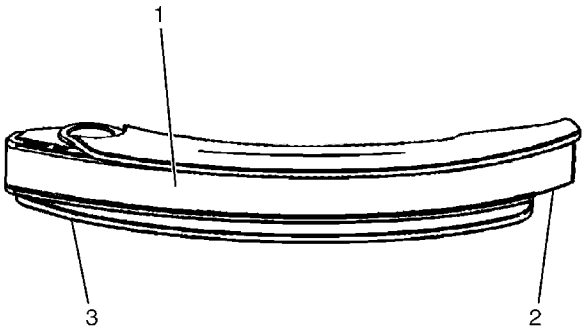


1. Inspect the right secondary timing chain guide for the following:
   - Worn guide surface (1)

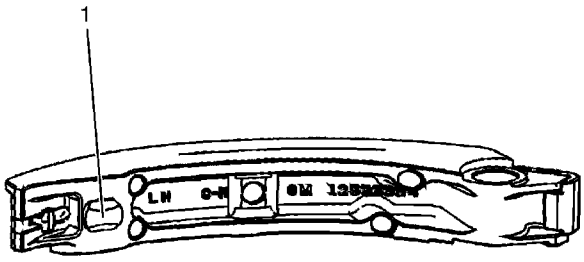
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged right secondary timing chain guide.

Left Secondary Timing Chain Shoe

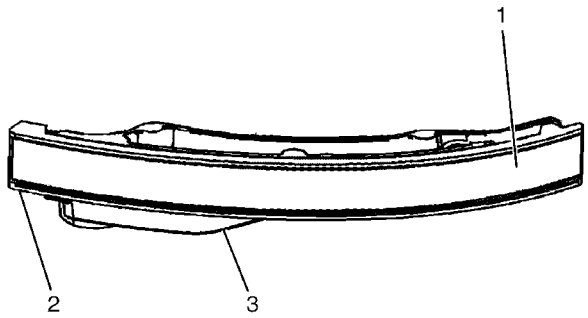


1. Inspect the front of the left secondary timing chain shoe for the following:
   - Worn shoe surface (1)
   - Cracked or broken shoe surface (2)
   - Cracked or damaged shoe (3)

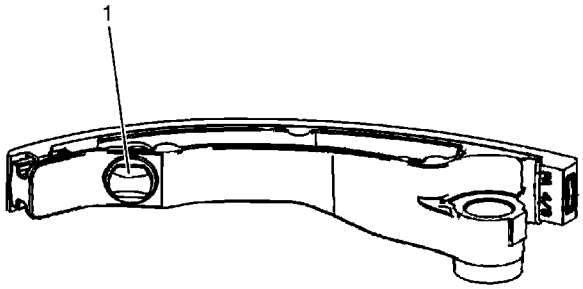


2. Inspect the back of the left secondary timing chain shoe for a damaged, worn or missing left secondary timing chain tensioner contact pad (1).
3. Replace a damaged left secondary timing chain shoe.

Right Secondary Timing Chain Shoe

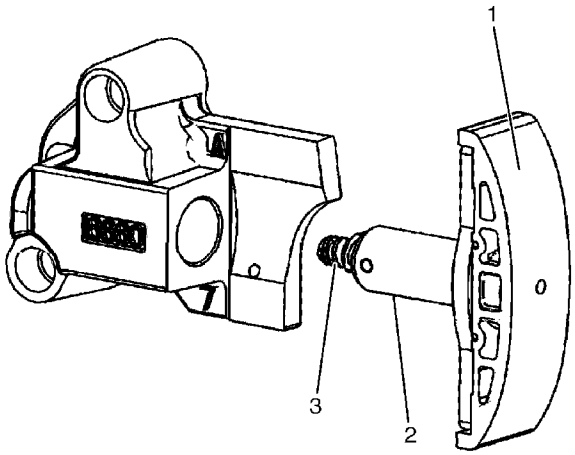


1. Inspect the front of the right secondary timing chain shoe for the following:
   - Worn shoe surface (1)
   - Cracked or broken shoe surface (2)
   - Cracked or damaged shoe (3)



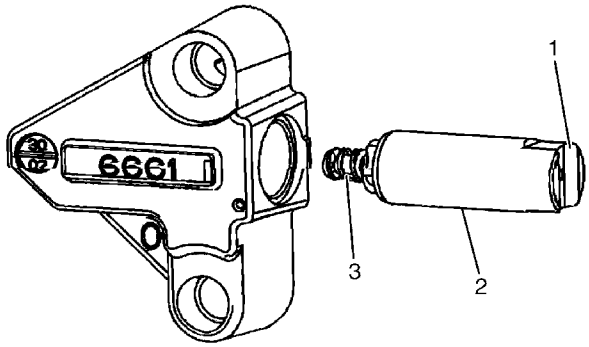
2. Inspect the back of the right secondary timing chain shoe for a damaged, worn or missing right secondary timing chain tensioner contact pad (1).
3. Replace a damaged right secondary timing chain shoe.

Primary Timing Chain Tensioner



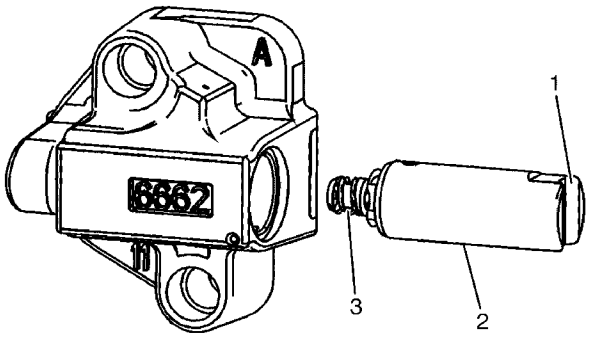
1. Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).
2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to Primary Camshaft Intermediate Drive Chain Tensioner Removal.
3. Replace a damaged primary timing chain tensioner.

Left Secondary Timing Chain Tensioner



1. Inspect the left secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the left secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to Secondary Camshaft Drive Chain Tensioner Installation - Left Side.
3. Replace a damaged left secondary timing chain tensioner.

Right Secondary Timing Chain Tensioner



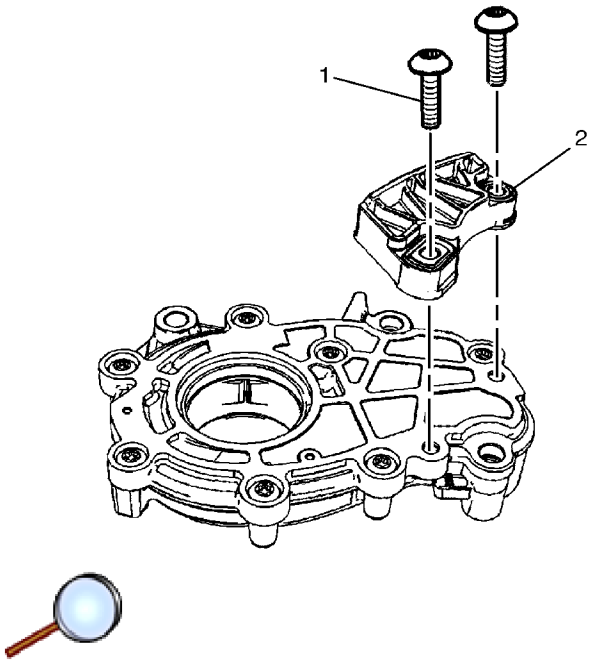
1. Inspect the right secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the right secondary timing chain tensioner for locked or binding timing chain

tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to Secondary Camshaft Drive Chain Tensioner Installation - Right Side.

3. Replace a damaged right secondary timing chain tensioner.

Oil Pump Disassemble

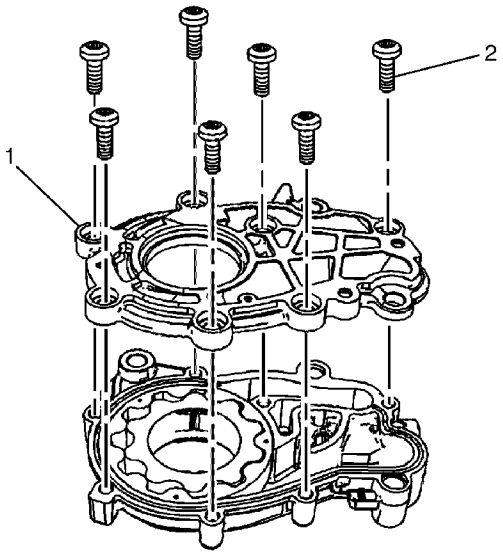
Important: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.



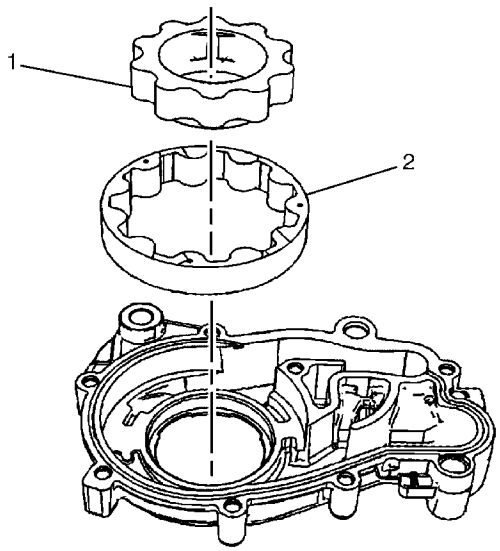
Important: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

1. Remove the primary camshaft drive chain lower guide to oil pump retaining bolts (1).
2. Remove the primary camshaft drive chain lower guide (2).

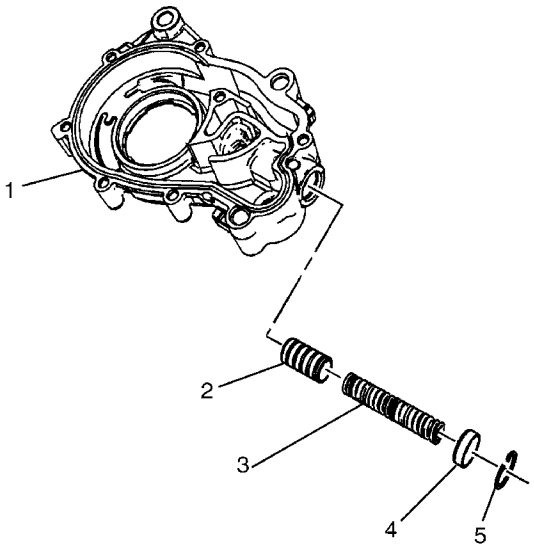
© 2010 General Motors Corporation. All rights reserved.



3. Remove the oil pump cover to the oil pump housing retaining bolts (2).
4. Remove the oil pump cover (1).



5. Remove the inner oil pump drive gear (1).
6. Remove the outer oil pump driven gear (2).



7. Remove the clip (5), holding the cap (4), for the oil relief valve components.
8. Remove the cap (4), spring (3) and plunger (2) from the oil pump housing (1).

Oil Pump Cleaning and Inspection

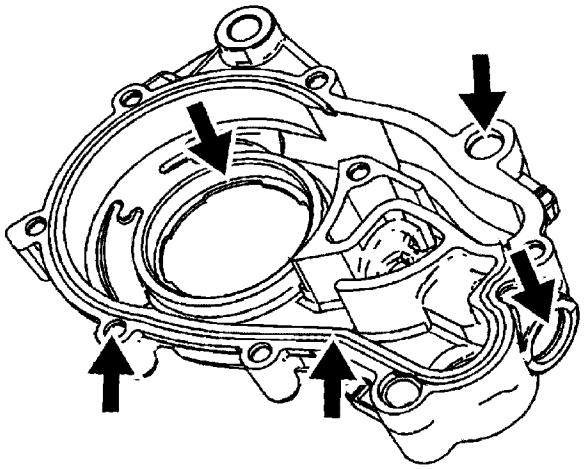
Cleaning Procedure

1. Clean the oil pump components with non-corrosive solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the oil pump components with compressed air.

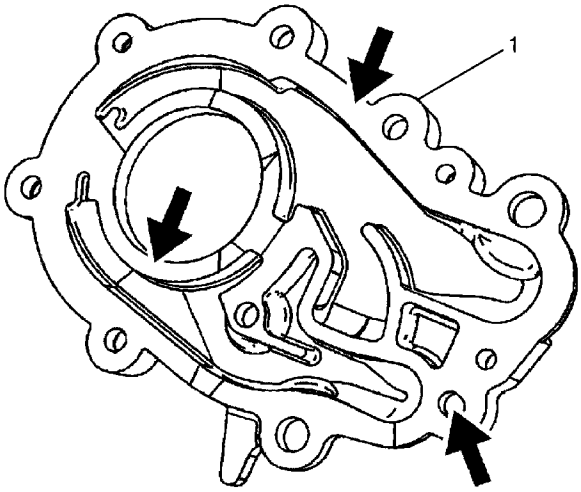
Inspection Procedure



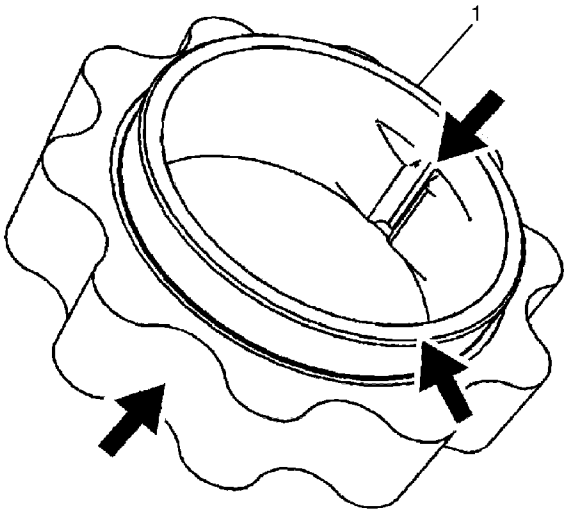
Note: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

1. Inspect the oil pump housing for damage.

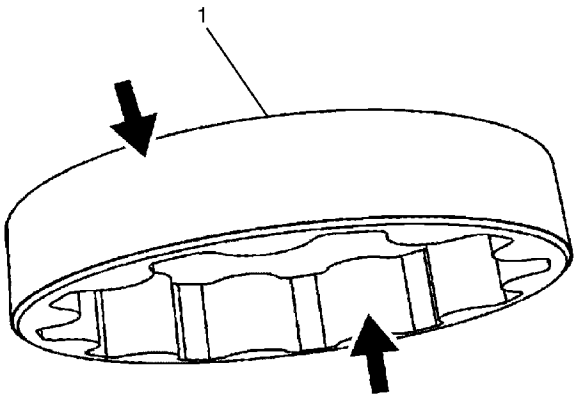
© 2010 General Motors Corporation. All rights reserved.



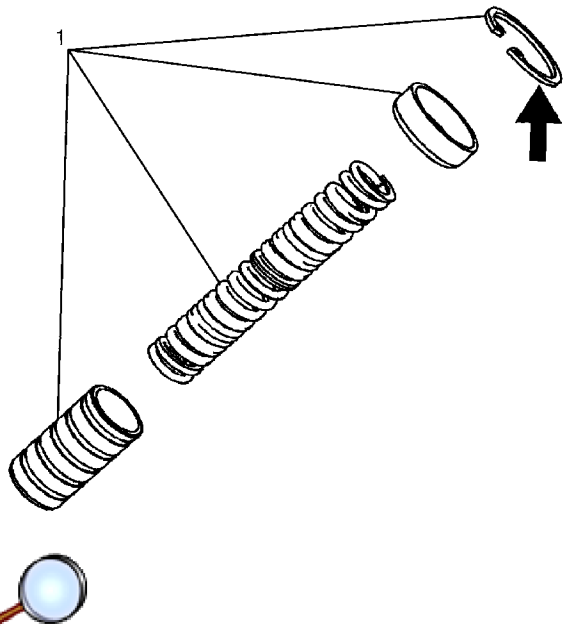
2. Inspect the oil pump cover (1) for damage.



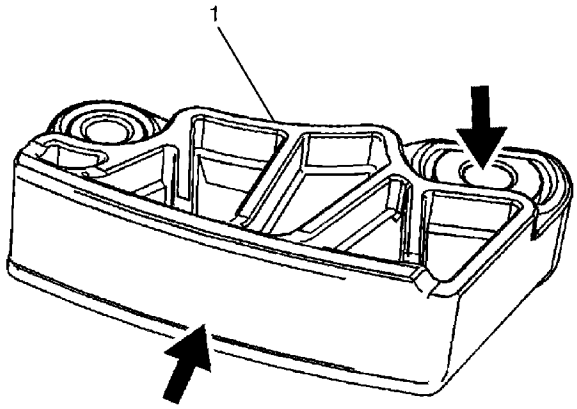
3. Inspect the inner drive gear (1) for damage. If inner diameter damage is found, ensure the crankshaft is also inspected.



4. Inspect the outer driven gear (1) for damage.

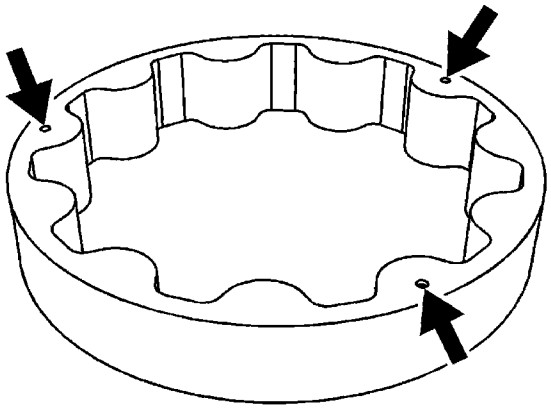


5. Inspect the oil pump relief valve components (1) for debris or damage.



6. Inspect the primary camshaft drive chain lower guide (1) for damage. If replacement of the primary camshaft drive chain lower guide (1) is necessary, replace the entire oil pump assembly. The primary camshaft drive chain lower guide (1) is not serviceable separately.
7. If debris or damage is present within the oil pump, further inspection of all of the engine components is necessary.

Oil Pump Assemble

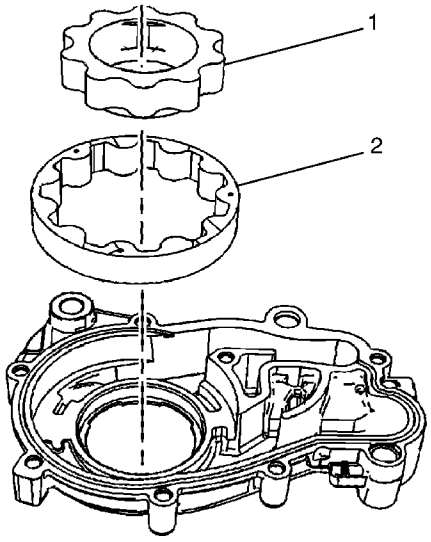


Note:

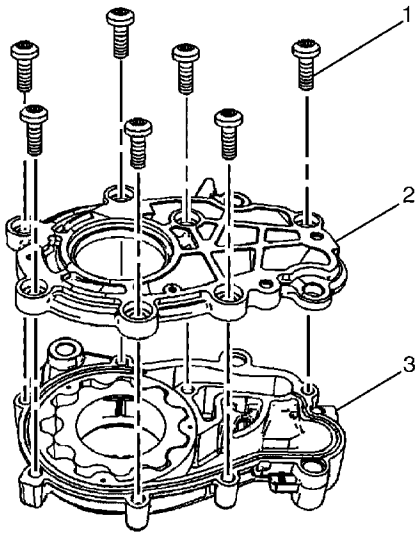
- There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must be replaced. DO NOT reuse a disassembled oil pump or a serviceable oil pump with a primary camshaft drive chain lower guide that needs to be replaced.
- The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

1. The dimpled surface must be face-up in the pump body.

© 2010 General Motors Corporation. All rights reserved.



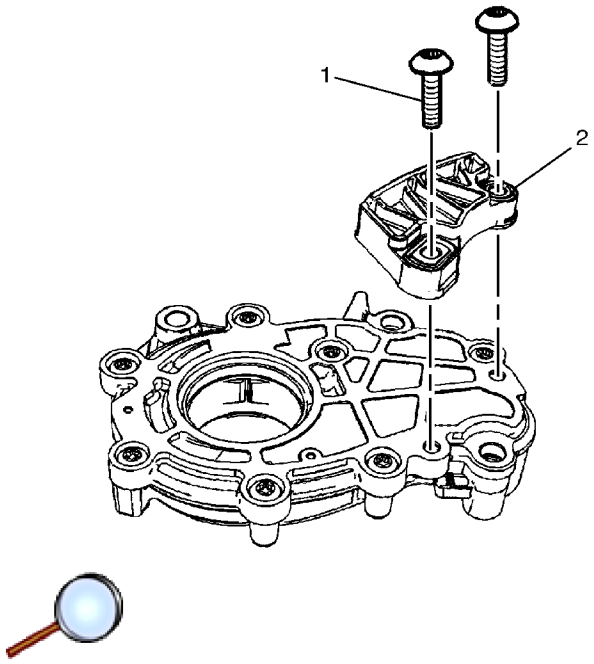
2. Install the inner oil pump drive gear (1) and the outer oil pump driven gear (2) in the pump cover in the same orientation as removed.



3. Install the oil pump cover (2) to the oil pump housing (3).

Caution: Refer to Fastener Caution in the Preface section.

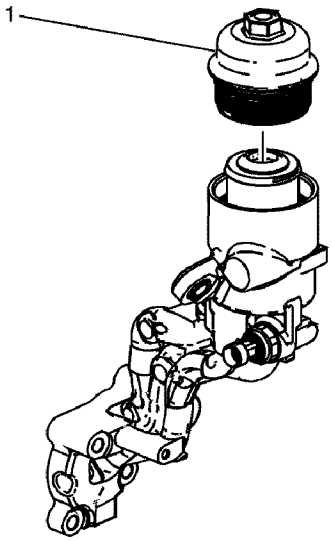
4. Install the oil pump cover to oil pump housing retaining bolts (1) and tighten to **10 N·m (89 lb in)**.



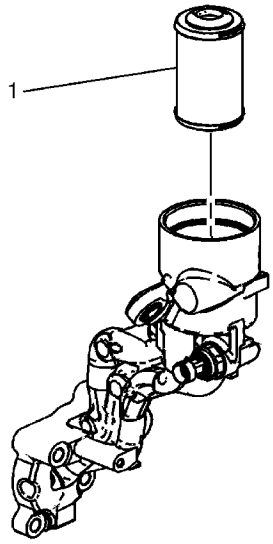
Note: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

5. Install the primary camshaft drive chain lower guide (2).
6. Install the primary camshaft drive chain lower guide to oil pump retaining bolts (1) and tighten to **13 N·m (115 lb in)**.

Oil Filter Adapter Disassemble



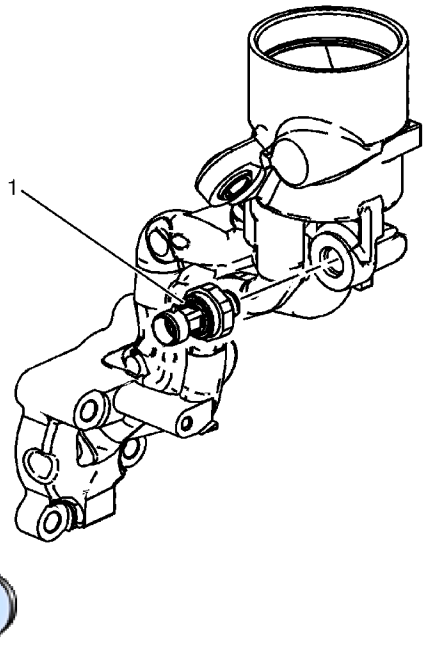
1. Remove the oil filter cap (1).



2. Remove the oil filter cartridge (1).

   Discard the oil filter cartridge (1).

© 2010 General Motors Corporation. All rights reserved.



3. Remove the oil pressure sender (1).

Oil Filter Adapter Cleaning and Inspection

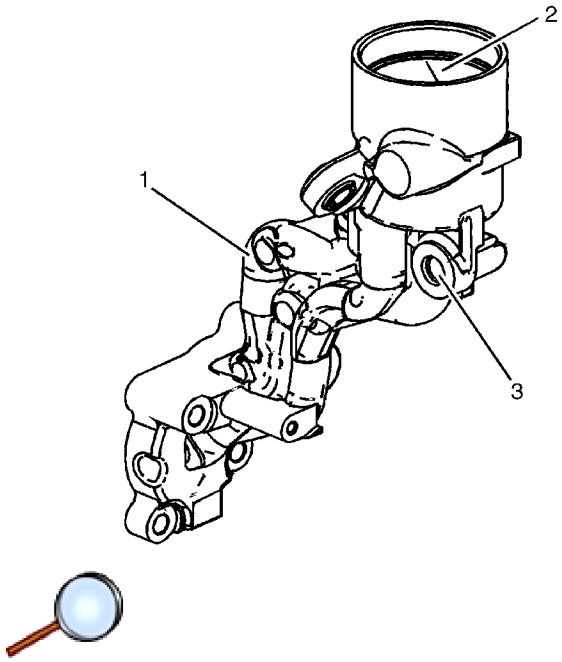
Cleaning Procedure

1. Clean the oil filter adapter components with non-corrosive solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the oil filter adapter components with compressed air.

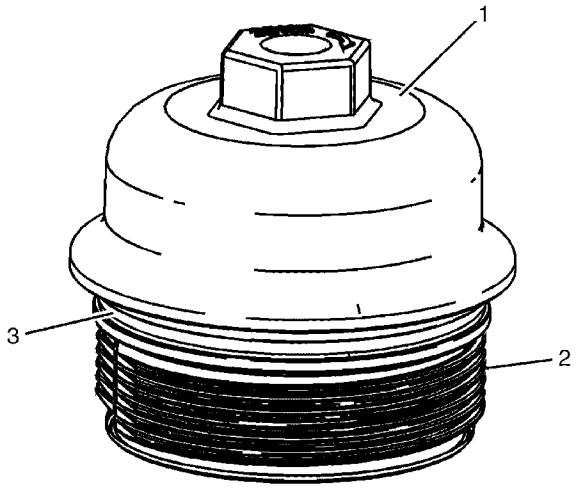
Inspection Procedure



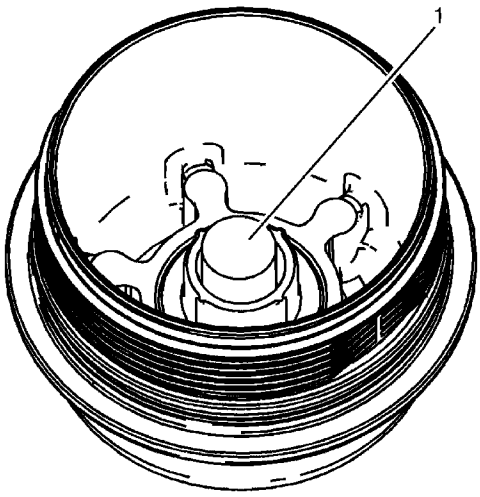
Note: The internal parts of the oil filter adapter are not serviced separately. If wear or damage is noted, replace the entire oil filter adapter assembly.

1. Inspect the oil filter housing for cracks, scoring, casting imperfections (1) and damaged threads (3).
2. Inspect the drain back valve (2) for damage or blockage.

© 2010 General Motors Corporation. All rights reserved.



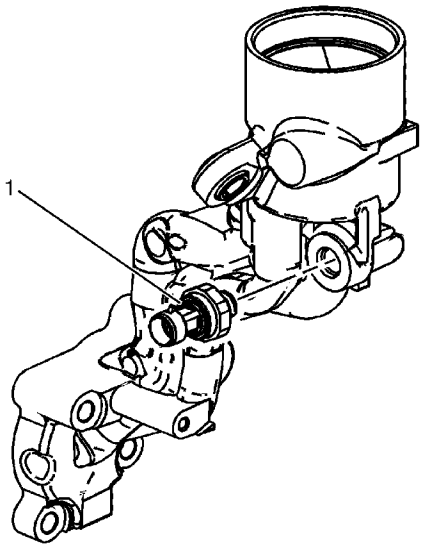
3. Inspect the oil filter cap for cracks, scoring, casting imperfections (1) and damaged threads (2). Replace as necessary.
4. Inspect the oil filter cap O-ring (3) for damage. Replace as necessary.



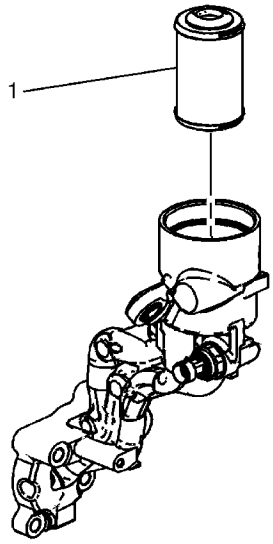
5. Inspect the bypass valve (1) for damage or blockage.

Oil Filter Adapter Assemble

Caution: Refer to Fastener Caution in the Preface section.

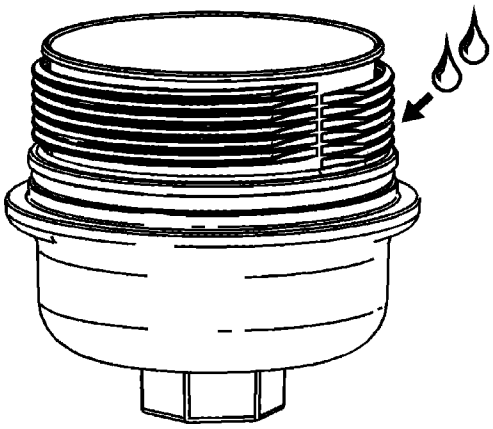


1. Install the oil pressure sender (1) and tighten to **20 N·m (15 lb in)**.



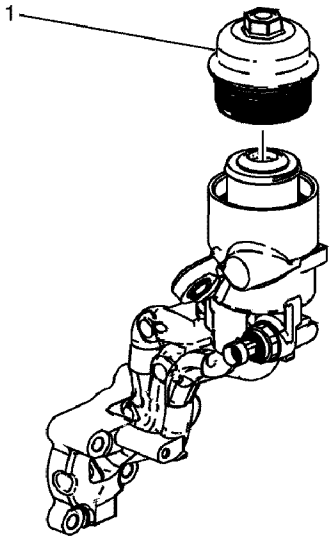
2. Install the NEW oil filter cartridge (1).

© 2010 General Motors Corporation. All rights reserved.



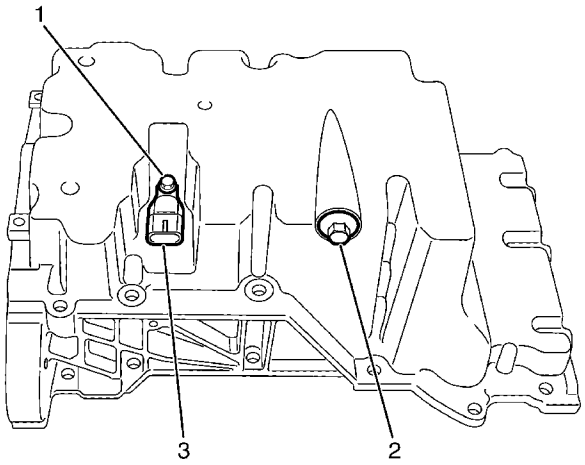
Caution: Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

3. Lubricate the oil filter cap threads with clean engine oil.

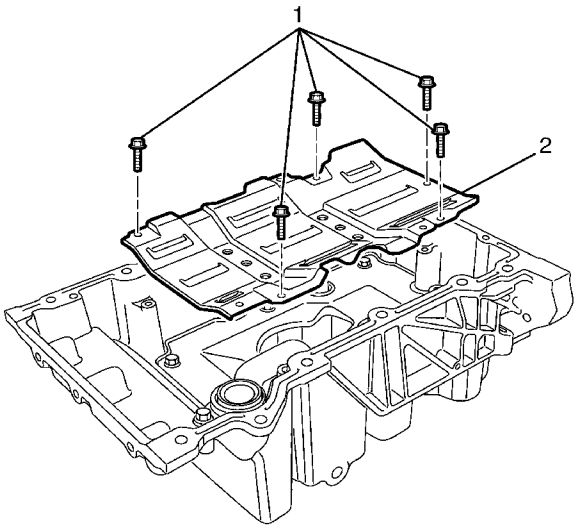


4. Install the oil filter cap (1) and tighten to **25 N·m (18 lb in)**.

Oil Pan Disassemble

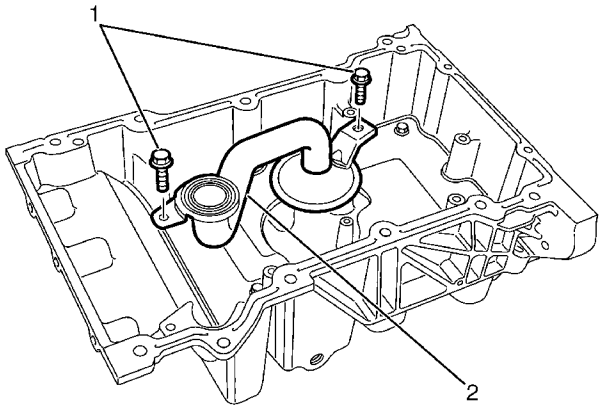


1. Remove the oil level sensor to oil pan retaining bolt (1).
2. Remove the oil level sensor (3).
3. Remove the oil pan drain plug (2).

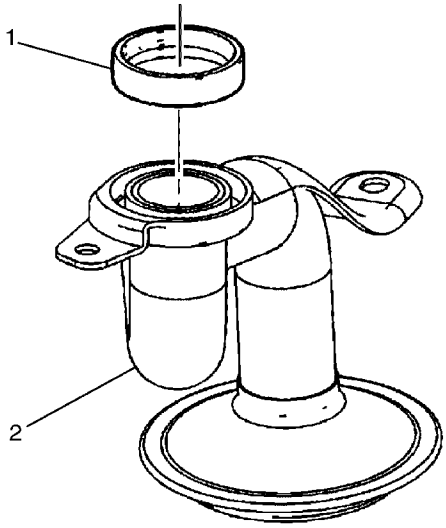


4. Remove the oil pan scraper to oil pan retaining bolts (1).
5. Remove the oil pan scraper (2).

© 2010 General Motors Corporation. All rights reserved.



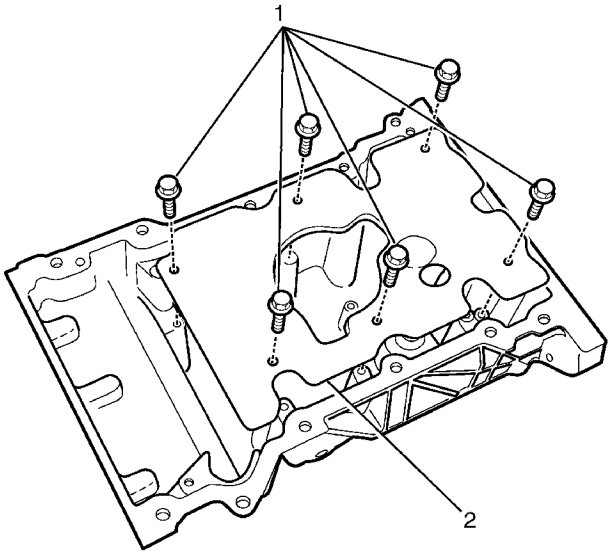
6. Remove the oil suction pipe to oil pan retaining bolts (1).
7. Remove the oil suction pipe (2).



Important: The oil suction pipe seal (1) is a single use component and must be discarded whenever the oil suction pipe (2) is removed.

8. Remove the oil suction pipe seal (1) from the oil suction pipe (2).

   Discard the oil suction pipe seal (1).



9. Remove the oil pan baffle to oil pan retaining bolts (1).
10. Remove the oil pan baffle (2).

Oil Pan Cleaning and Inspection

Special Tools

J 28410 Gasket Remover

For equivalent regional tools, refer to Special Tools.

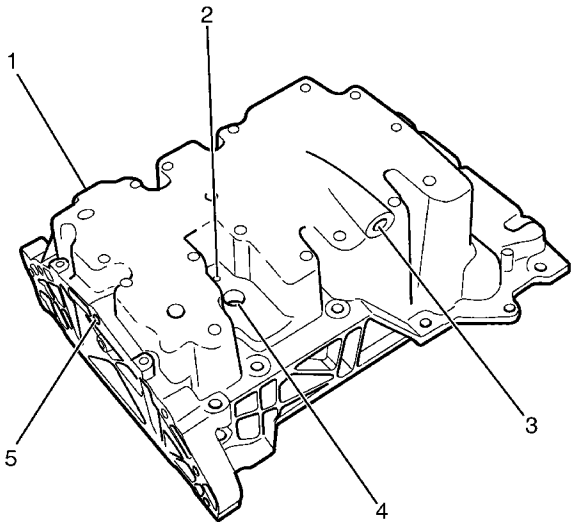
Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using *J 28410* remover
2. Clean the oil pan and oil pan components in solvent.
3. Clean out any debris from the bolt holes.

   Warning: Refer to Safety Glasses Warning in the Preface section.

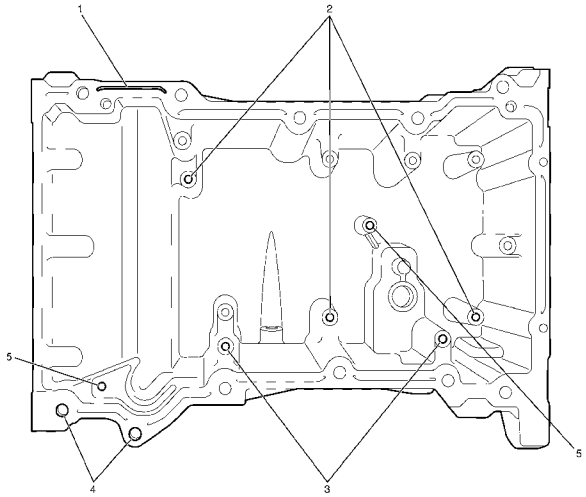
4. Dry the oil pan and oil pan components with compressed air.

Inspection Procedure

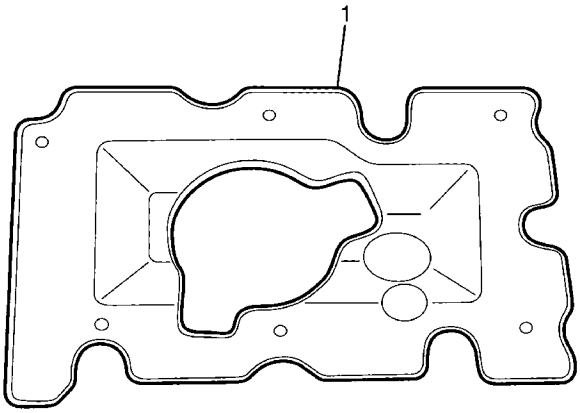


1. Inspect the exterior of the oil pan for the following conditions:
   - Damage to the drain plug or drain plug hole (3).
   - Damage to the transmission mounting bosses (5).
   - Damage to the oil level/condition sensor bolt hole threads (2).
   - Damage to the oil level/condition sensor hole (4).
   - Dents or damage to the exterior (1).

© 2010 General Motors Corporation. All rights reserved.



2. Inspect the interior of the oil pan for the following conditions:
   - Gouges or damage to the oil pan sealing surfaces (1).
   - Damage to the oil pan baffle mounting bosses (2).
   - Damage to the bolt holes (3).
   - Damage to the oil suction pipe mounting bosses (4).
   - Damage to the oil pan scraper mounting bosses (5).
3. Inspect the oil pan scraper for damage.



4. Inspect the oil pan baffle (1) for damage.
5. Repair or replace the oil pan and/or oil pan components as necessary.

Oil Pump Suction Pipe and Screen Cleaning and Inspection

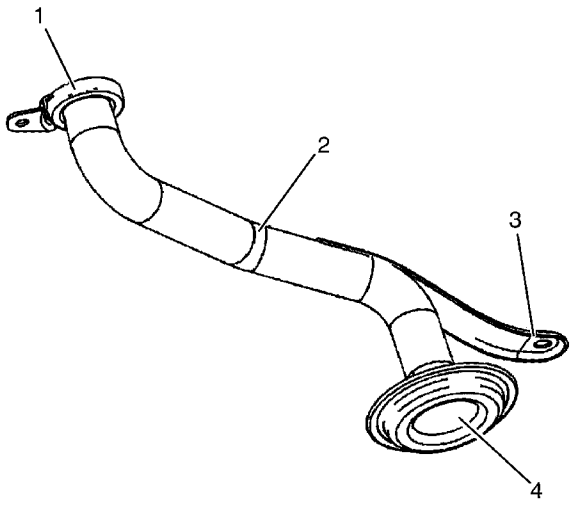
Cleaning Procedure

1. Clean the oil pump pipe and screen with solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the oil pump pipe and screen with compressed air.

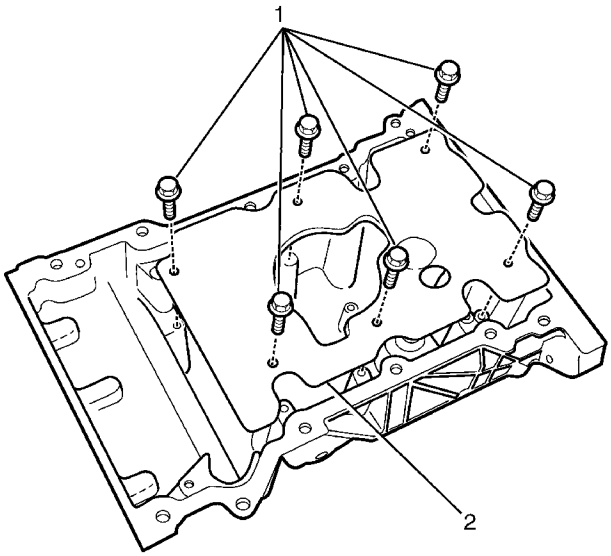
Inspection Procedure



1. Inspect the mounting surface (1) for possible leakage paths.
2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump pipe support bracket (3) for cracks or damage.
4. Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

© 2010 General Motors Corporation. All rights reserved.

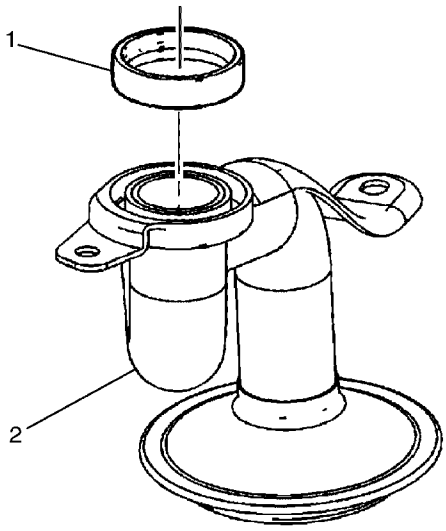
Oil Pan Assemble



1. Install the oil pan baffle (2).

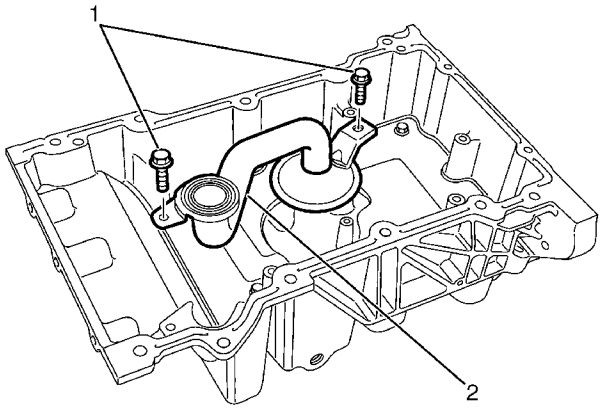
Caution: Refer to Fastener Caution in the Preface section.

2. Install the oil pan baffle to oil pan retaining bolts (1) and tighten to **10 N·m (89 lb in)**.

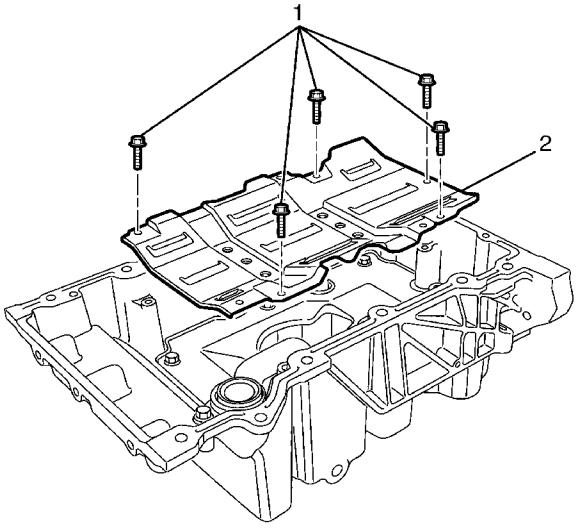


3. Install a NEW oil suction pipe seal (1) onto the oil suction pipe (2).

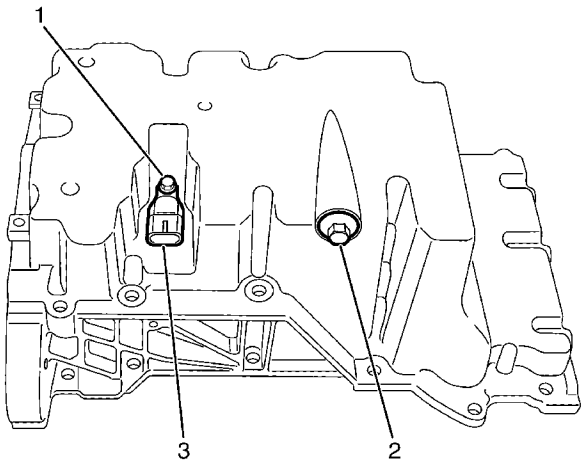
© 2010 General Motors Corporation. All rights reserved.



4. Install the oil suction pipe (2).
5. Install the oil suction pipe to oil pan retaining bolts (1) and tighten to **10 N·m (89 lb in)**.



6. Install the oil pan scraper (2).
7. Install the oil pan scraper to oil pan retaining bolts (1) and tighten pan scraper bolts to **10 N·m (89 lb in)**.

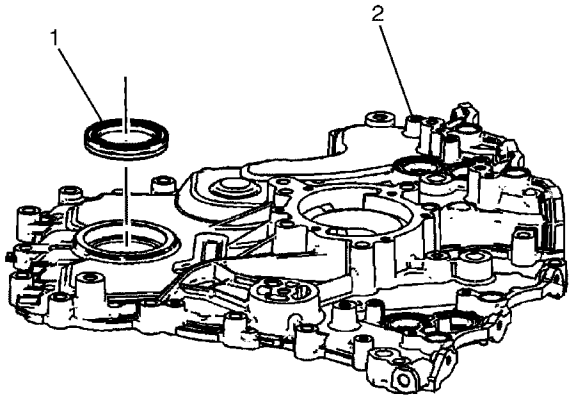


8. Install the oil pan drain plug (2) and tighten to **20 N·m (15 lb ft)**.
9. Install the oil level sensor (3).
10. Install the oil level sensor to oil pan retaining bolt (1) and tighten to **10 N·m (89 lb in)**.

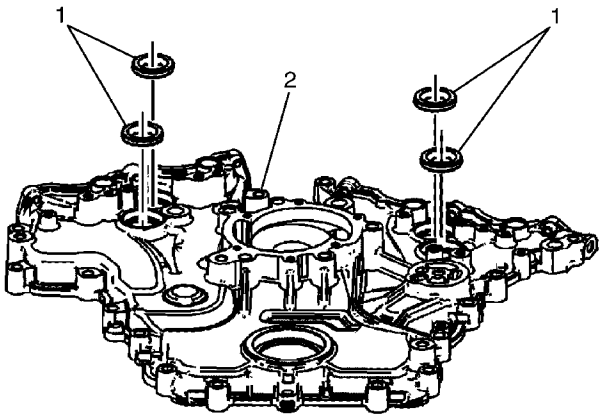
Engine Front Cover Disassemble

Tools Required

E-308 Seal Remover



1. Remove the crankshaft front oil (1) seal from the engine front cover (2) using the E-308 .



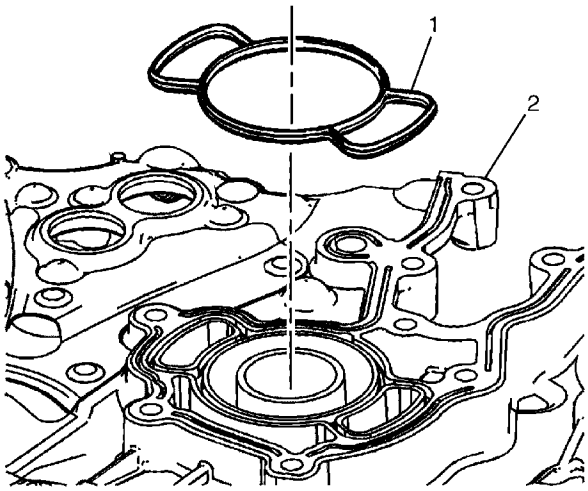
© 2010 General Motors Corporation. All rights reserved.

Important: LE0 and LW2 engines only have an intake camshaft position actuator solenoid.

Important: The camshaft position actuator solenoid valve oil seals (1) must be discarded whenever the camshaft position actuator solenoids have been removed from the front cover (2).

2. Remove the camshaft position actuator solenoid seals (1) from the engine front cover (2).

   Discard the seals



Important: The water pump seal (1) must be discarded whenever the water pump has been removed from the front cover (2).

3. Remove the water pump seal (1) from the engine front cover (2).

   Discard the seal

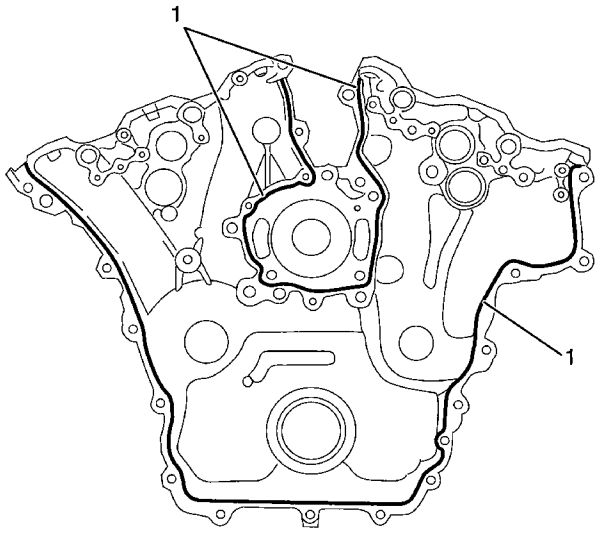
Engine Front Cover Cleaning and Inspection

Special Tools

J 28410 Gasket Remover

For equivalent regional tools, refer to Special Tools.

Cleaning Procedure



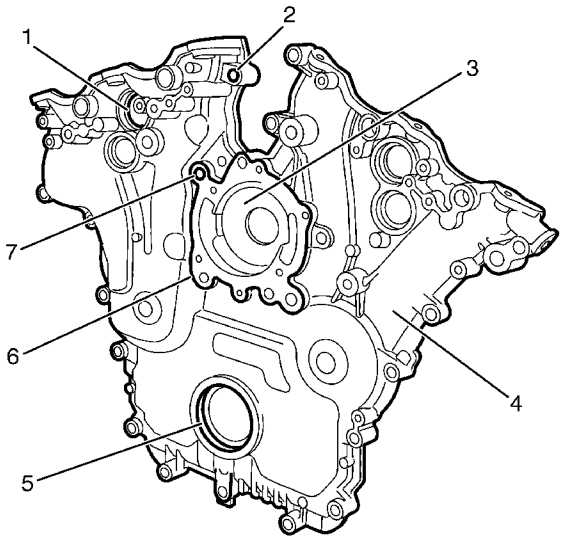
1. Remove any RTV sealant (1) from the engine front cover using *J 28410* remover .
2. Clean out debris from the bolt holes.
3. Clean the engine front cover (1) in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

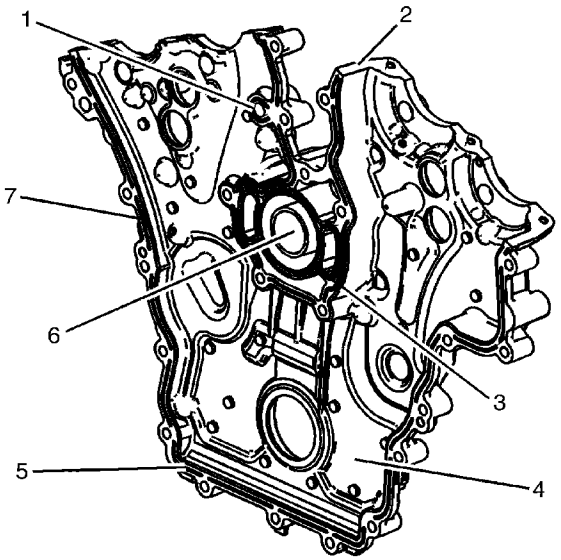
4. Dry the engine front cover (1) with compressed air.

Inspection Procedure

© 2010 General Motors Corporation. All rights reserved.



1. Inspect the exterior of the engine front cover for the following conditions:
   - Damage to the water pump bolt hole threads (7).
   - Gouges or damage to the water pump sealing surfaces (6).
   - Damage to the crankshaft front oil seal bore (5).
   - Damage to the camshaft position actuator solenoid seal bores (1).
   - Damage to the engine front cover bolt holes (2).
   - Damage and/or corrosion to the engine coolant passage (3).
   - Dents or damage to the exterior (4).



2. Inspect the interior of the engine front cover for the following conditions:
   - Gouges or damage to the engine front cover sealing surfaces to the cylinder block (7), oil

pan (5), and/or camshaft covers (2).

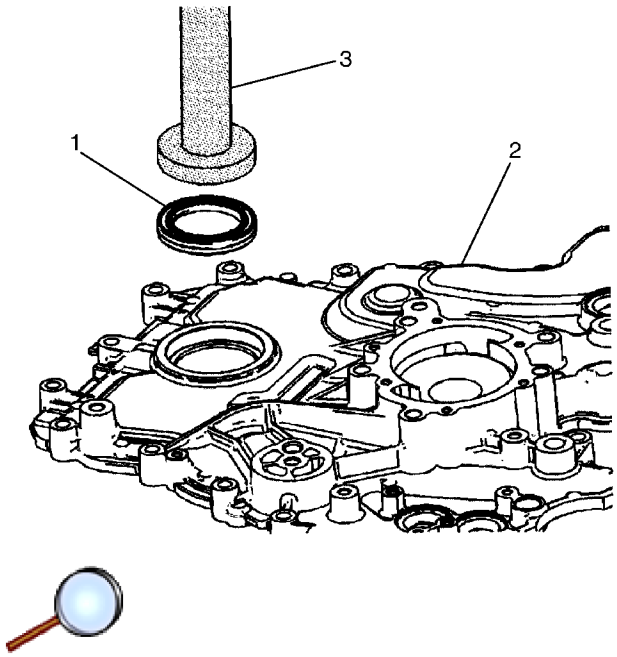
- Damage and/or corrosion to the engine coolant passage .(6)
- Damage to the crankshaft front oil seal bore.
- Gouges or damage to the O-ring sealing areas.
- Gouges or damage to the water pump seal area (3).
- Loose or damaged deadener plates (4).
- Damage to the engine front cover bolt holes (1).

3. Repair or replace the engine front cover as necessary.

Engine Front Cover Assemble

Tools Required

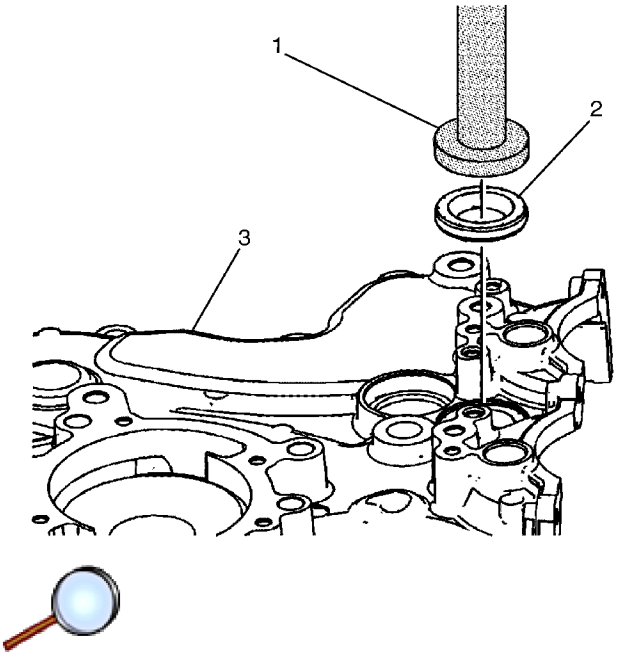
- EN-46103 Camshaft Actuator Valve Seal Remover/Installer
- J 29184 Oil Seal Installer



Important: DO NOT lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

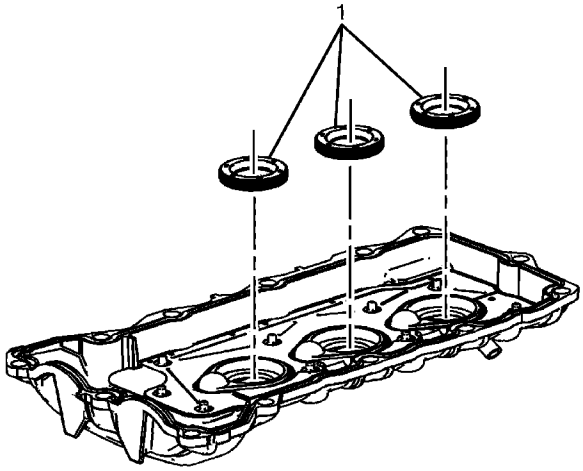
1. Install the NEW crankshaft front oil seal into the engine front cover using the J 29184 .

© 2010 General Motors Corporation. All rights reserved.



2. Install the NEW camshaft position actuator solenoid seals into the engine front cover using the EN-46103 .

Camshaft Cover Disassemble



Remove and discard the ignition coil seals (1).

© 2010 General Motors Corporation. All rights reserved.

Camshaft Cover Cleaning and Inspection

Cleaning Procedure

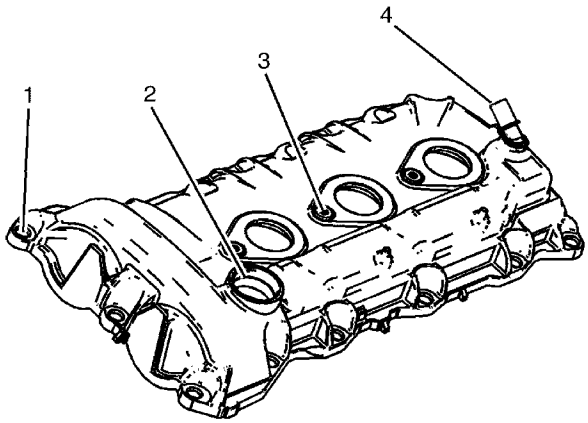
1. Clean the camshaft covers in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the camshaft covers with compressed air.

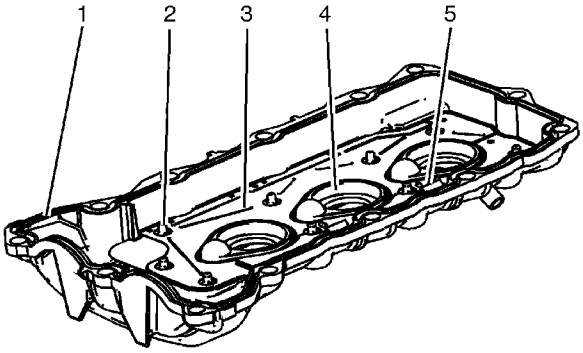
Inspection Procedure

1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
   - Leak engine oil.
   - Effect crankcase ventilation.
   - Interfere with the camshafts.
   - Interfere with the ignition coil sealing.
   - Allow water or condensation to enter the engine.

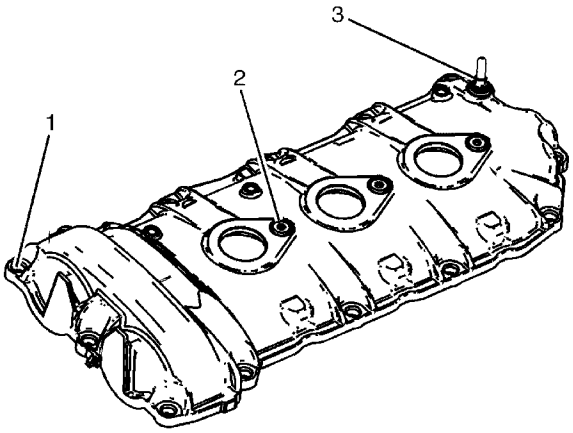


2. Inspect the exterior of the left camshaft cover for the following conditions:
   - Damage to the camshaft cover bolt holes (1).
   - Damage to the oil fill hole (2).
   - Damage to the mounting holes (3) for the ignition coil assembly.
   - Damage to the Positive Crankcase Ventilation (PCV) hose connector (4) -- A damaged PCV hose connector is replaceable.

© 2010 General Motors Corporation. All rights reserved.

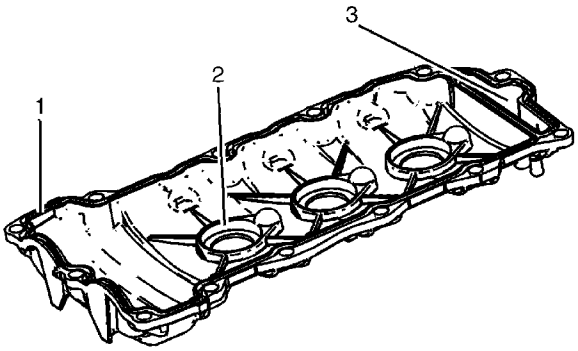


3. Inspect the interior of the left camshaft cover for the following conditions:
   - Gouges or damage to the camshaft cover sealing groove (1).
   - Damaged, loose or missing baffle fasteners (2).
   - Damaged, loose or missing baffle (3).
   - Gouges or damage to the ignition coil seal bore (4).
   - Restrictions to the ventilation system (5).



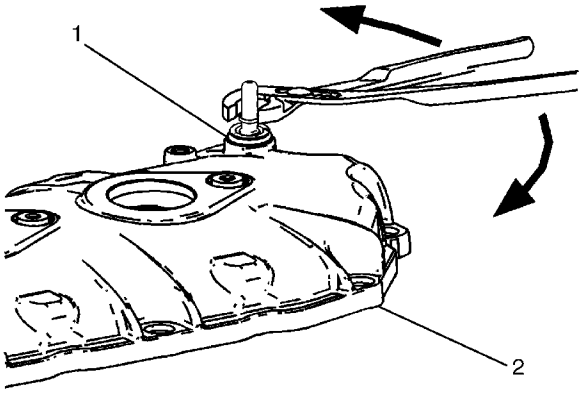
4. Inspect the exterior of the right camshaft cover for the following conditions:
   - Damage to the camshaft cover bolt holes (1).
   - Damage to the mounting holes (2) for the ignition coil assembly.

- Damage to the PCV orifice (3) -- A damaged PCV orifice can be replaced. Refer to PCV Orifice Replacement.



5. Inspect the interior of the right camshaft cover for the following conditions:
   - Gouges or damage to the camshaft cover sealing groove (1).
   - Gouges or damage to the ignition coil seal bore (2).
   - Restrictions to the ventilation system (3).
6. Repair or replace the camshaft cover or covers as necessary.

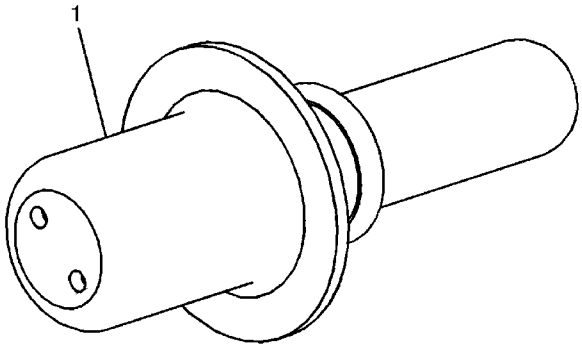
PCV Orifice Replacement



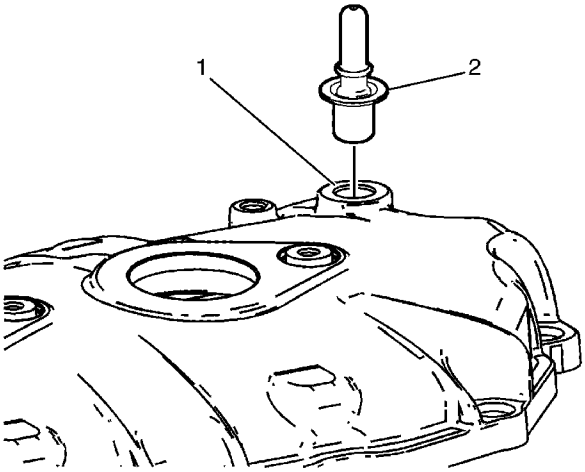
Note: If the PCV orifice is damaged or plugged and cannot be cleaned out, the PCV orifice can be replaced.

Note: Remove the PCV orifice (1) by griping the neck of the PCV orifice (1) with pliers and twisting and pulling out of the right camshaft cover (2).

1. Remove the PCV orifice (1) from the right camshaft cover (2).

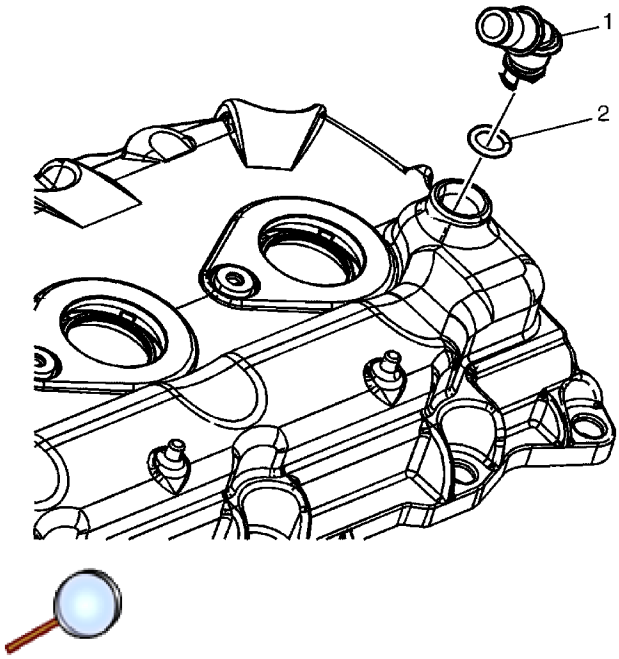


2. Apply a GM approved sealant to the NEW PCV orifice (1).



3. Install the NEW PCV orifice (2) into the right camshaft cover (1). After insertion, twist the PCV orifice (2) in order to address any vertical leak paths in the sealant.

PCV Fitting Replacement

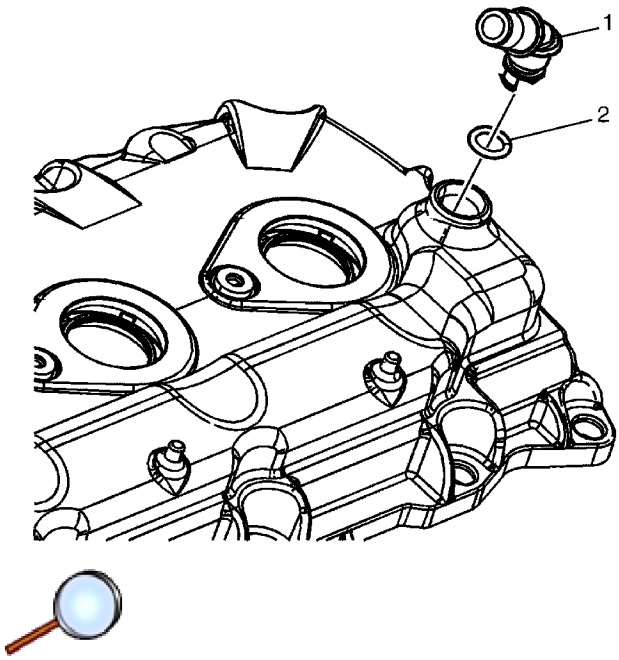


Note: If the PCV fitting (1) is damaged or plugged and cannot be cleaned out, the PCV fitting (1) can be replaced.

Note: The PCV fitting O-ring (2) is a single use component and must be discarded whenever the PCV fitting (1) is removed.

1. Remove the PCV fitting (1).

   Discard the PCV fitting O-ring (2).

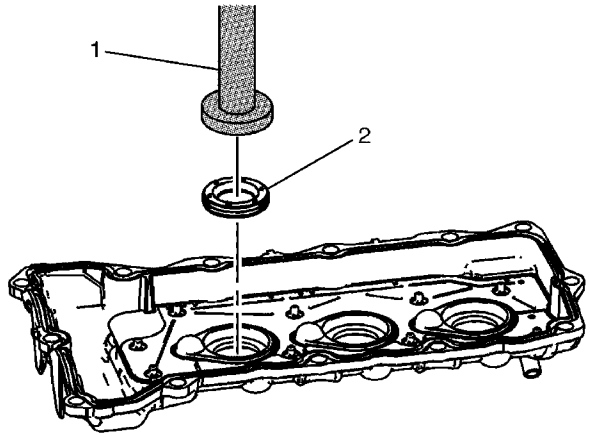


2. Install the NEW PCV fitting (1) with a NEW PCV fitting O-ring (2).

Camshaft Cover Assemble

Tools Required

J 24254 Oil Seal Installer

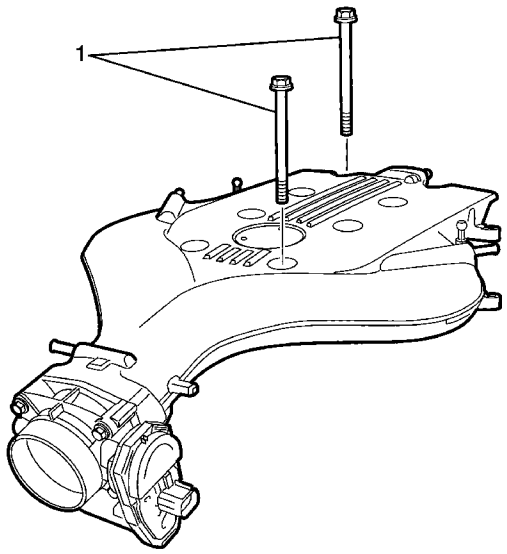


Install the NEW ignition coil seals (2) using the J 24254 (1).

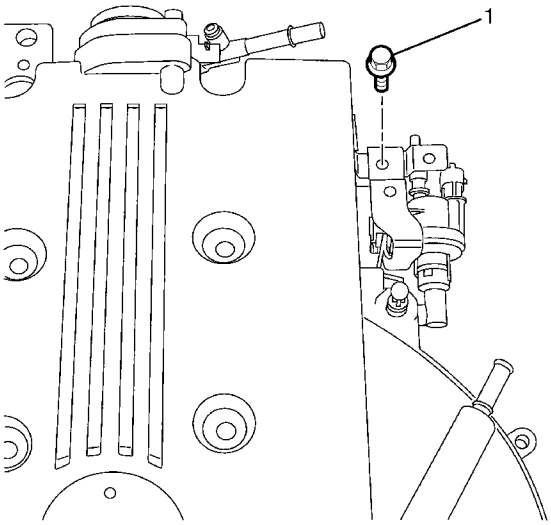
© 2010 General Motors Corporation. All rights reserved.

Intake Manifold Disassemble

Upper to Lower Intake Manifold Disassemble Procedure

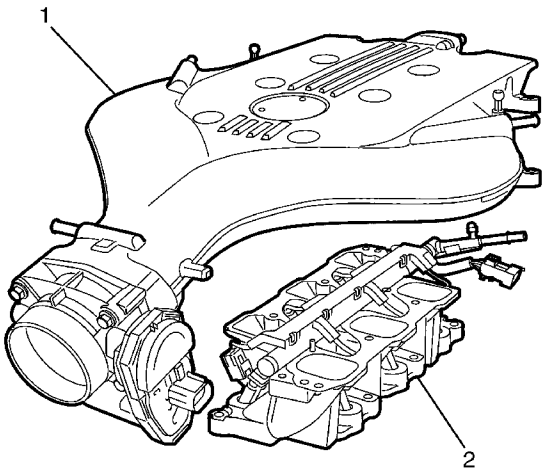


1. Remove the upper-to-lower intake manifold retaining bolts (1).

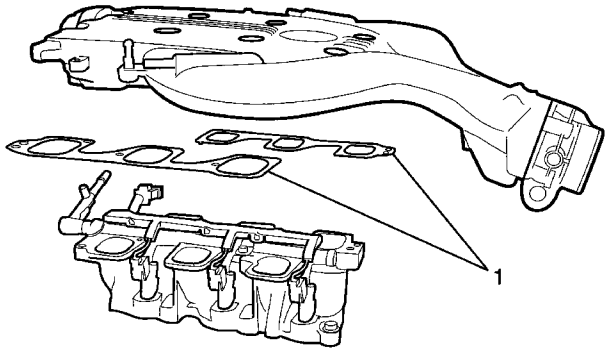


2. Remove the fuel injector wiring harness bracket to upper intake manifold retaining bolt (1).

© 2010 General Motors Corporation. All rights reserved.



3. Remove the upper intake manifold (1) from the lower intake manifold (2).

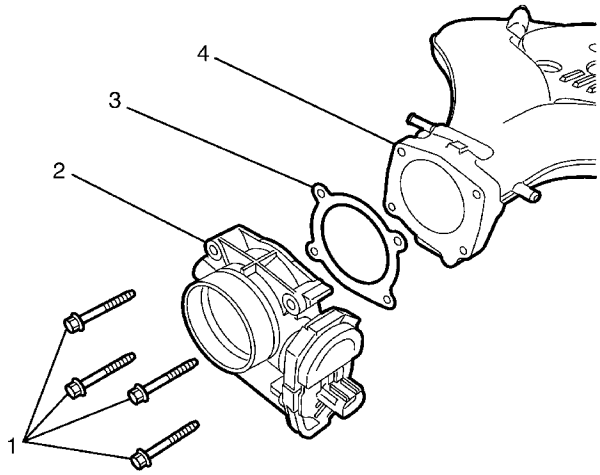


Important: DO NOT reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.

4. Remove the upper-to-lower intake manifold gaskets (1).

   Discard the upper-to-lower intake manifold gaskets (1).

Upper Intake Manifold Disassemble Procedure

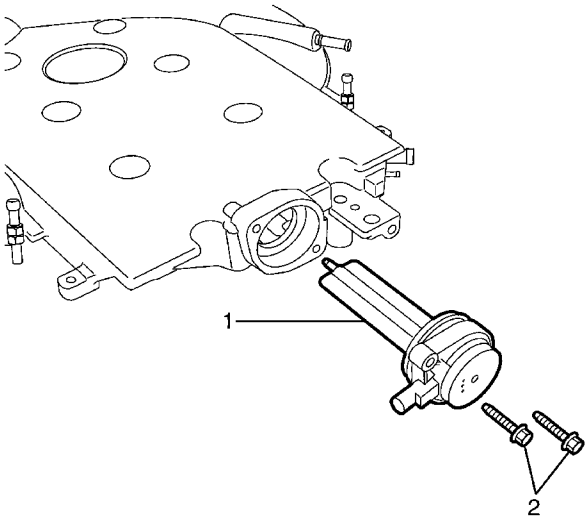


1. Remove the throttle body bolts to upper intake manifold retaining bolts (1).
2. Remove the throttle body (2).

Important: The throttle body gasket (3) must be discarded whenever the throttle body (2) has been removed from the upper intake manifold (4).

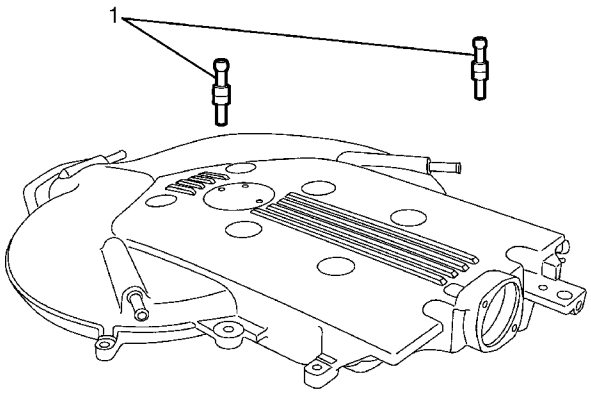
3. Remove the throttle body gasket (3).

   Discard the gasket



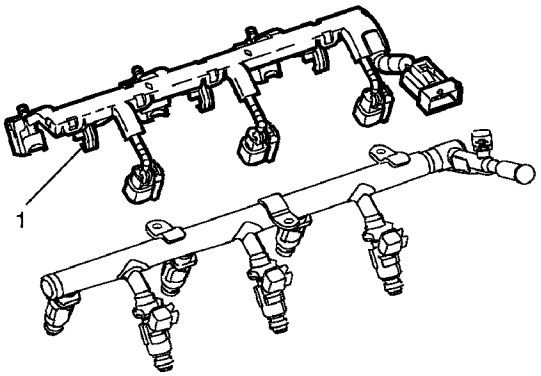
4. Remove the Intake Manifold Runner Control (IMRC) flap to upper intake manifold retaining bolts (2).

5. Remove the IMRC flap (1).

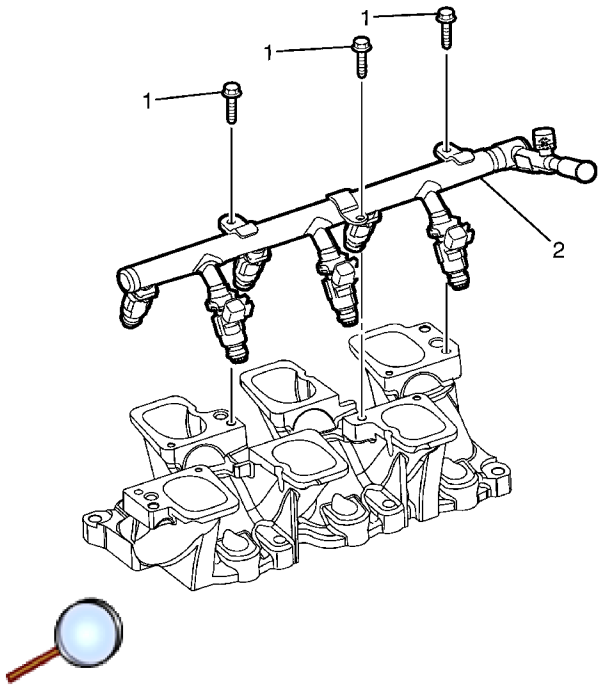


6. Remove the sight shield ball studs (1).

Lower Intake Manifold Disassemble Procedure



1. Remove the fuel injector wiring harness (1).



2. Remove the fuel injector rail to lower intake manifold retaining bolts (1).
3. Remove the fuel injector rail (2).

Intake Manifold Cleaning and Inspection

Upper Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Throttle body.
   - Intake manifold.
2. Clean the following intake manifold areas in solvent.
   - Intake manifold gasket sealing areas.
   - Intake manifold passages.
   - Brake booster hose passage.
   - Evaporative emission (EVAP) solenoid passage.
   - Positive Crankcase Ventilation (PCV) vacuum hose passages.

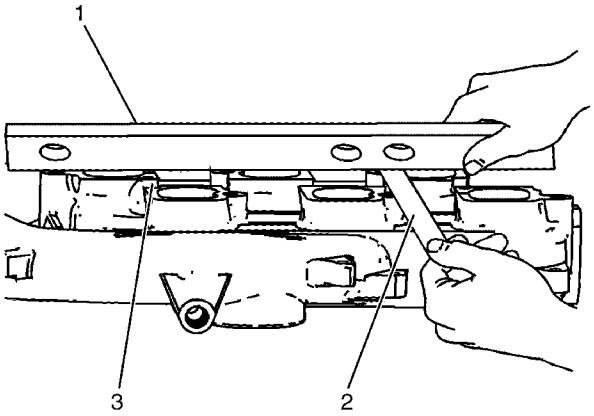
   Warning: Refer to Safety Glasses Warning in the Preface section.

3. Dry the upper intake manifold and throttle body with compressed air.

Inspection Procedure

1. Inspect the upper intake manifold for the following conditions:
   - Damage, debris or restrictions to the brake vacuum booster hose port.
   - Damage to the throttle body bolt holes.
   - Damage, debris or restrictions to the PCV system hose ports.
   - Damage to the intake manifold bolt bosses.
   - Damage to the EVAP purge solenoid mounting boss.
   - Damage, debris or restrictions to the EVAP purge solenoid port.
   - Damage, debris or restrictions in the vacuum passage.
   - Damage to the intake manifold runner control flap mounting bosses.
   - Damage, debris or restrictions to the intake manifold runner control flap port.
   - Damage to the intake manifold runner control flap components.
   - Gouges or damage to the upper intake manifold sealing surfaces.
   - Damage to the gasket sealing surface for the throttle body.

© 2010 General Motors Corporation. All rights reserved.



2. Inspect the upper intake manifold sealing surface for warpage.
   2.1. Locate a straight edge (1) across the upper-to-lower intake manifold sealing surface (3).
   2.2. Insert a feeler gauge (2) between the upper-to-lower intake manifold sealing surface (3) and the straight edge (1). An upper intake manifold with warpage in excess of 0.05 mm (0.020 in) must be replaced.
3. Repair or replace the upper intake manifold as necessary.

Lower Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Upper-to-lower intake manifold sealing surface.
   - Cylinder head-to-lower intake manifold sealing surface.
2. Clean the following intake manifold areas in solvent.
   - Intake manifold gasket sealing surfaces.
   - Intake manifold passages.

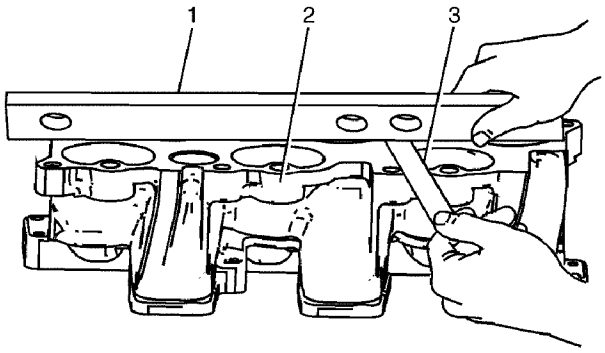
   Warning: Refer to Safety Glasses Warning in the Preface section.

3. Dry the intake manifold with compressed air.

Inspection Procedure

1. Inspect the lower intake manifold for the following conditions:
   - Damage, debris or restrictions to the lower intake manifold ports
   - Damage to the fuel rail mounting bolt holes
   - Damage to the fuel rail
   - Gouges or damage to the intake manifold sealing surfaces
   - Damage to the lower intake manifold bolt bosses

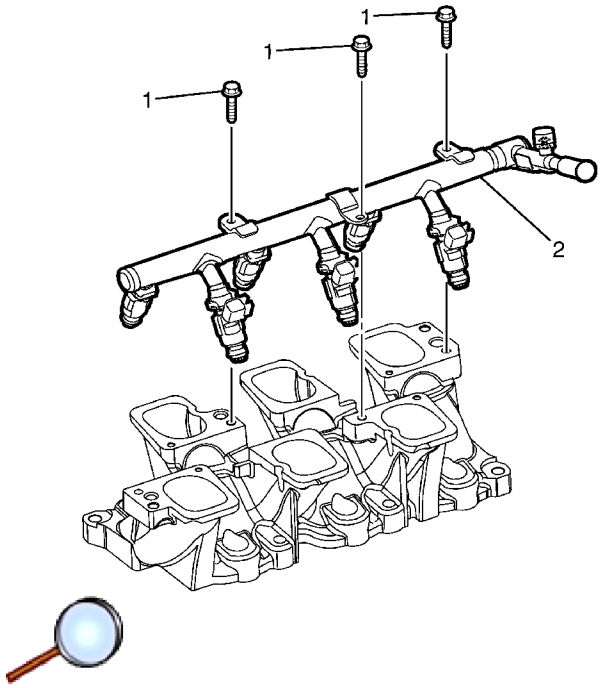
- Damage to the fuel injector ports



2. Inspect the lower intake manifold sealing surfaces for warpage.
   2.1. Locate a straight edge (1) across the lower intake manifold sealing surfaces (2).
   2.2. Insert a feeler gauge (3) between the lower intake manifold sealing surfaces (2) and the straight edge (1). A lower intake manifold with warpage in excess of 0.5 mm (0.020 in) must be replaced.
3. Repair or replace the lower intake manifold as necessary.

Intake Manifold Assemble

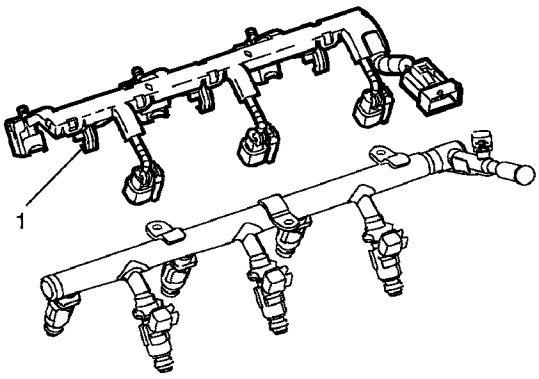
Lower Intake Manifold Assemble Procedure



1. Install the fuel injector rail (2).

   Caution: Refer to Fastener Caution in the Preface section.

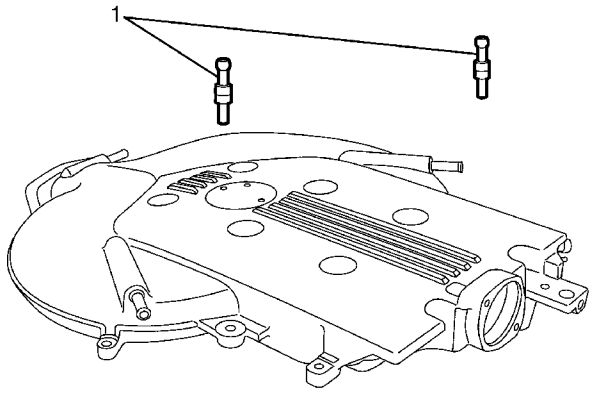
2. Install the fuel injector rail to lower intake manifold retaining bolts (1) and tighten fuel injector rail bolts to **10 N·m (89 lb in)**.



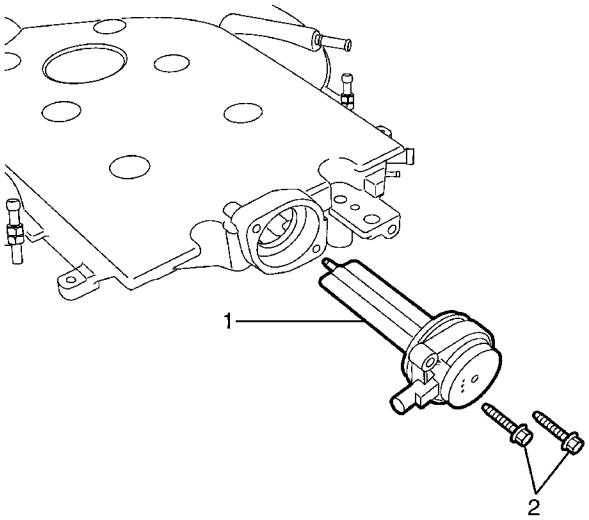
© 2010 General Motors Corporation. All rights reserved.

3. Install the fuel injector wiring harness (1).

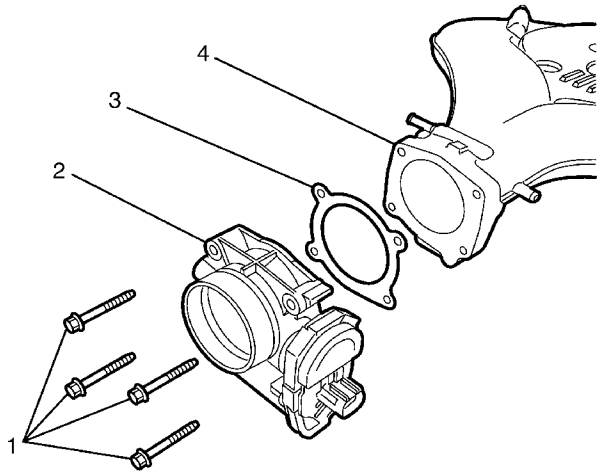
Upper Intake Manifold Assemble Procedure



1. Install the engine cover ball studs (1) and tighten to **7 N·m (62 lb in)**.

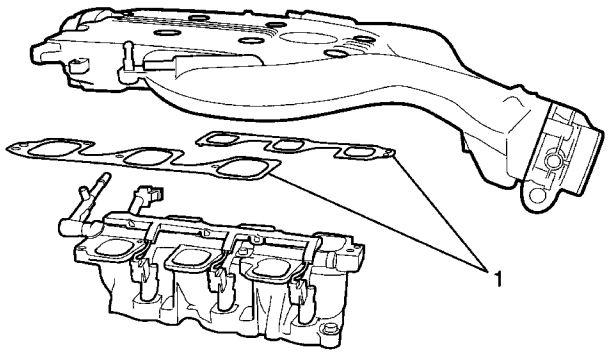


2. Install the Intake Manifold Runner Control (IMRC) flap (1).
3. Install the IMRC flap to upper intake manifold retaining bolts (2) and tighten to **10 N·m (89 lb in)**.



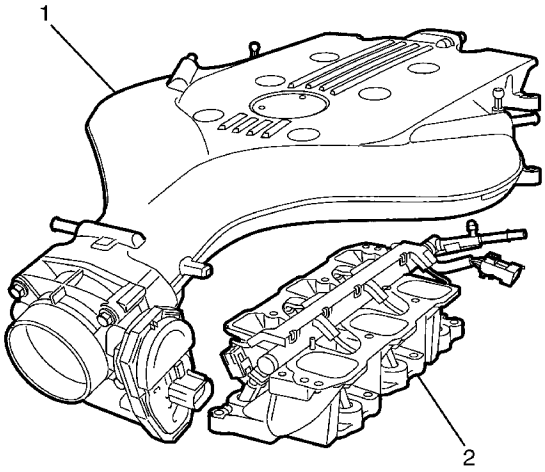
4. Install the NEW throttle body gasket (3) to the intake manifold (4).
5. Install the throttle body (2).
6. Install the throttle body bolts to upper intake manifold retaining bolts (1) and tighten to **10 N·m (89 lb in)**.

Upper to Lower Intake Manifold Assemble Procedure

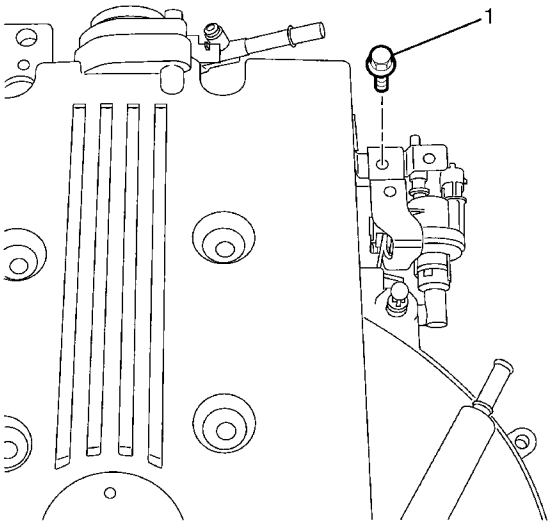


Note: DO NOT reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.

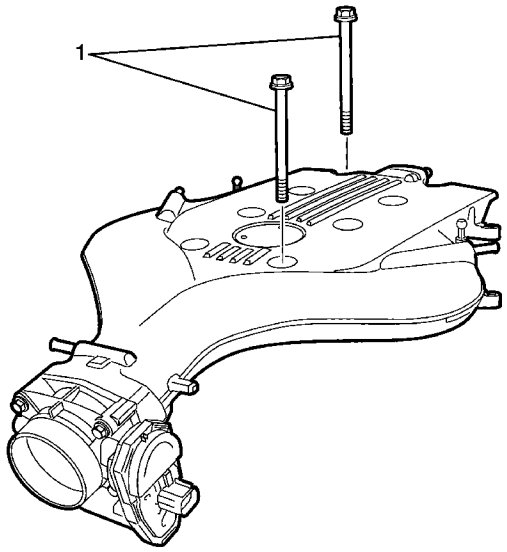
1. Install the NEW upper-to-lower intake manifold gaskets (1).



2. Install the upper intake manifold (1) to the lower intake manifold (2).



3. Install the fuel injector wiring harness bracket to upper intake manifold retaining bolt (1) and tighten to **10 N·m (89 lb in)**.



4. Install the upper-to-lower intake manifold retaining bolts (1) and tighten to **23 N·m (17 lb ft)**.

Exhaust Manifold Cleaning and Inspection - Left Side

Cleaning Procedure

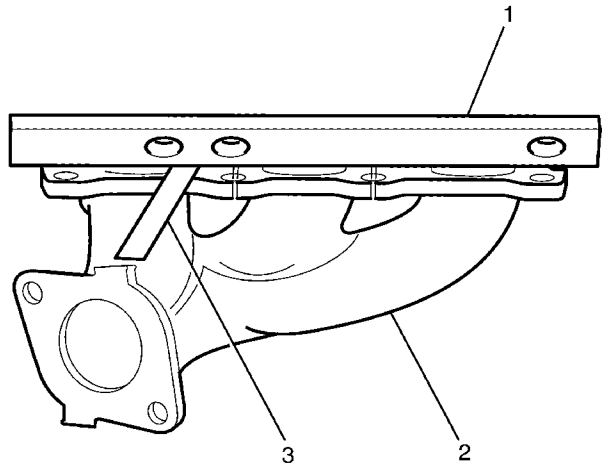
1. Clean the exhaust manifold in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the exhaust manifold with compressed air.

Inspection Procedure

1. Inspect the left exhaust manifold for the following:
   - Damage or corrosion above acceptable tolerances to the exhaust manifold exterior.
   - Damage to the exhaust manifold mounting holes.
   - Damage to the threaded holes for the heat shield.
   - Damage to the exhaust manifold flange bolt holes.
   - Damage to the gasket sealing surfaces.
   - Damage or restrictions within the exhaust passages.
2. Repair or replace the left exhaust manifold and/or components as necessary.



3. Measure the alignment or surface flatness of the exhaust manifold (2) flanges, using a straight edge (1) and a feeler gauge (3). Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
4. If the surface flatness is not within specifications, the exhaust manifold (2) is warped and must be replaced.

© 2010 General Motors Corporation. All rights reserved.

Exhaust Manifold Cleaning and Inspection - Right Side

Cleaning Procedure

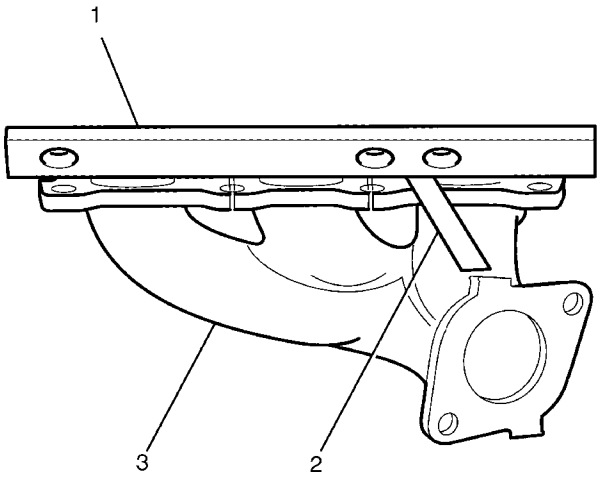
1. Clean the exhaust manifold in solvent.

   Warning: Refer to Safety Glasses Warning in the Preface section.

2. Dry the exhaust manifold with compressed air.

Inspection Procedure

1. Inspect the left exhaust manifold for the following:
   - Damage or corrosion above acceptable tolerances to the exhaust manifold exterior.
   - Damage to the exhaust manifold mounting holes.
   - Damage to the threaded holes for the heat shield.
   - Damage to the exhaust manifold flange bolt holes.
   - Damage to the gasket sealing surfaces.
   - Damage or restrictions within the exhaust passages.
2. Repair or replace the left exhaust manifold and/or components as necessary.



3. Measure the alignment or surface flatness of the exhaust manifold (3) flanges, using a straight edge (1) and a feeler gauge (2). Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
4. If the surface flatness is not within specifications, the exhaust manifold (3) is warped and must be replaced.

© 2010 General Motors Corporation. All rights reserved.

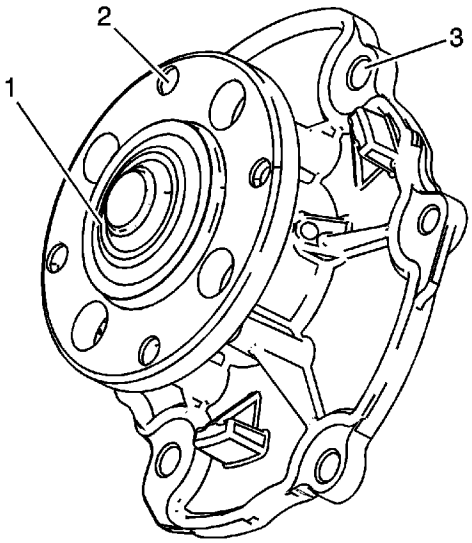
Water Pump Cleaning and Inspection

Cleaning Procedure

Caution: Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

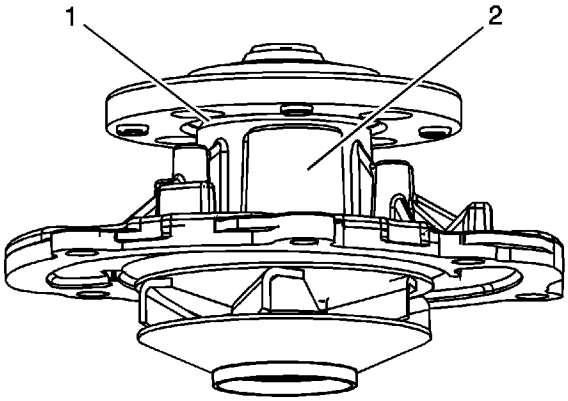
1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.

Inspection Procedure

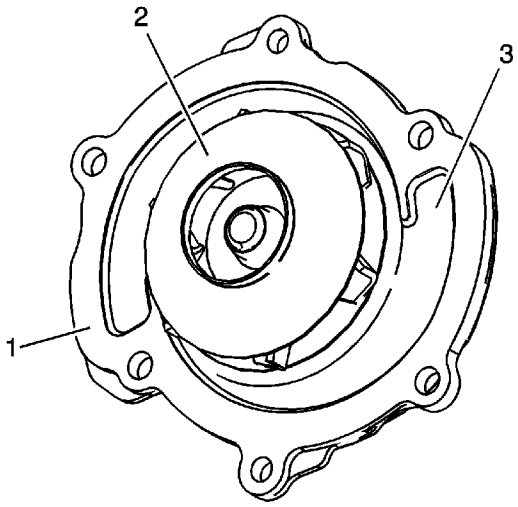


1. Rotate the water pump hub (1). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.
2. Inspect the exterior of the water pump for the following:
   - Damage to the water pump hub bolt threads (2) for the water pump pulley
   - Damage to the water pump bolt holes (3)

© 2010 General Motors Corporation. All rights reserved.

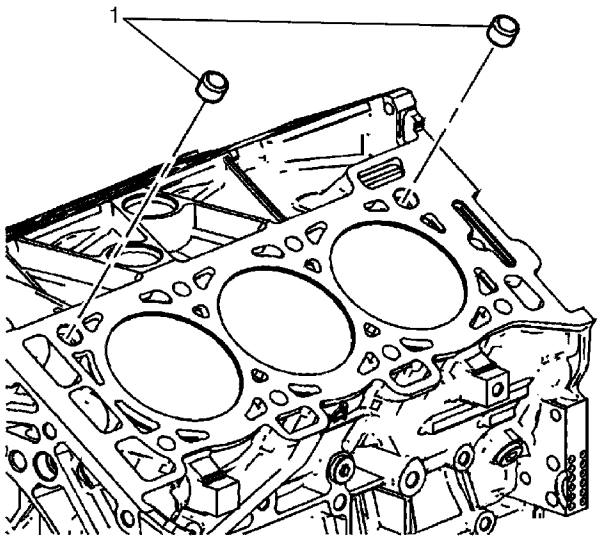


3. Examine the water pump shaft (1) and the weep hole reservoir (2) in the water pump body for signs of leakage. If coolant leakage is evident, replace the water pump.

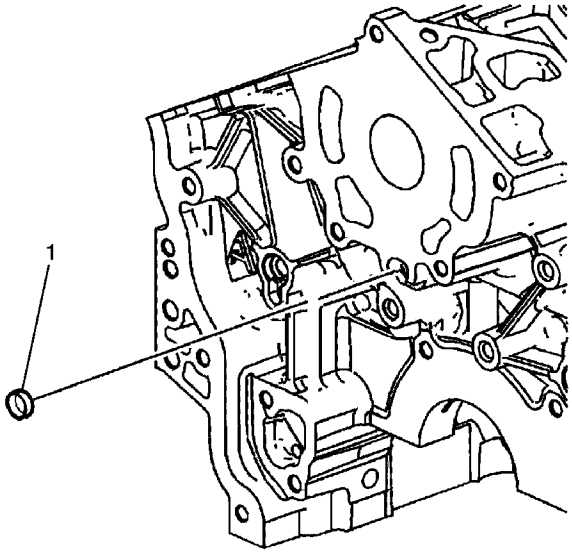


4. Inspect the interior of the water pump for the following:
   - Damage to the water pump gasket sealing surface (1)
   - Damage, corrosion or restrictions to the water pump impeller (2)
   - Damage, corrosion or restrictions to the coolant passages (3)
5. Repair or replace the water pump as necessary.

Engine Block Assemble

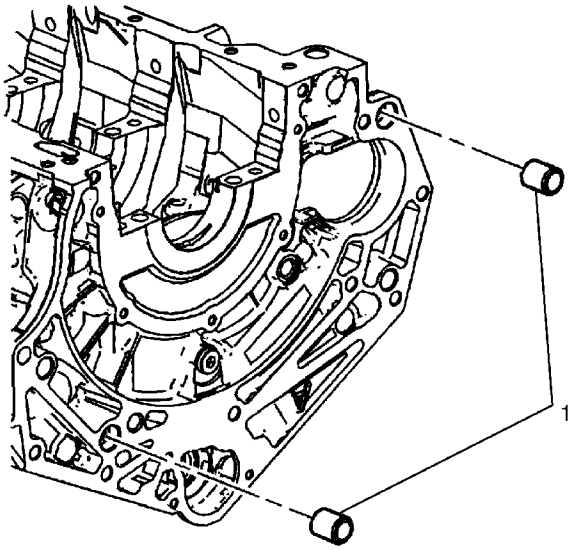


1. Install the cylinder block-to-cylinder head alignment dowels (1).

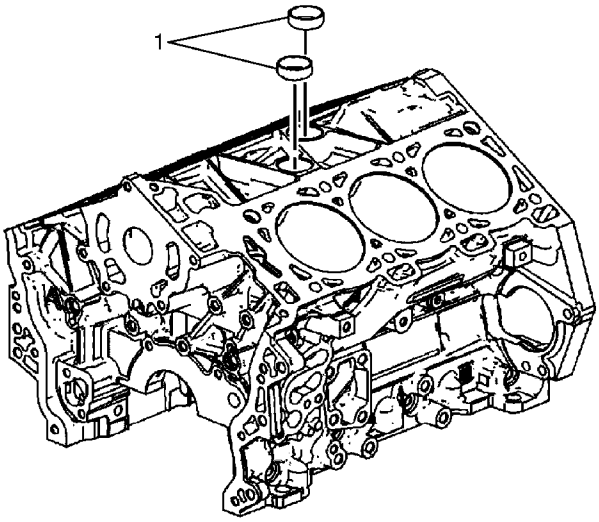


2. Install the NEW front oil gallery expansion plug (1).
3. Make sure the NEW front oil gallery expansion plug (1) is installed to the correct depth.

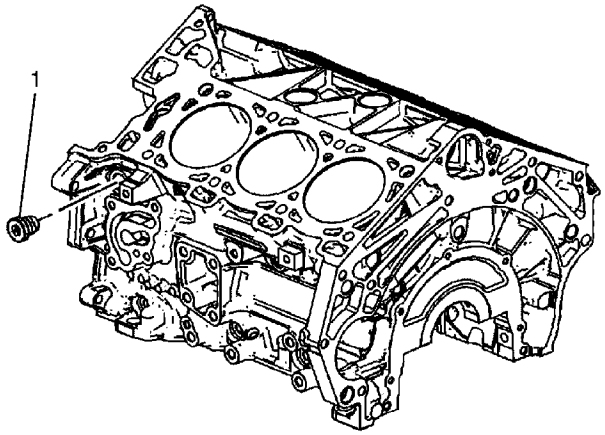
© 2010 General Motors Corporation. All rights reserved.



4. Install the cylinder block-to-transmission alignment dowels (1).



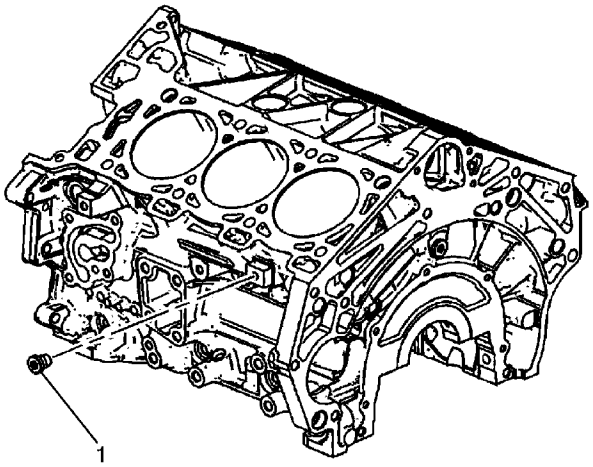
5. Apply RTV sealant on the NEW coolant expansion plugs (1).
6. Install the NEW coolant expansion plugs (1).
7. Make sure the NEW coolant expansion plugs (1) are installed to the correct depth.



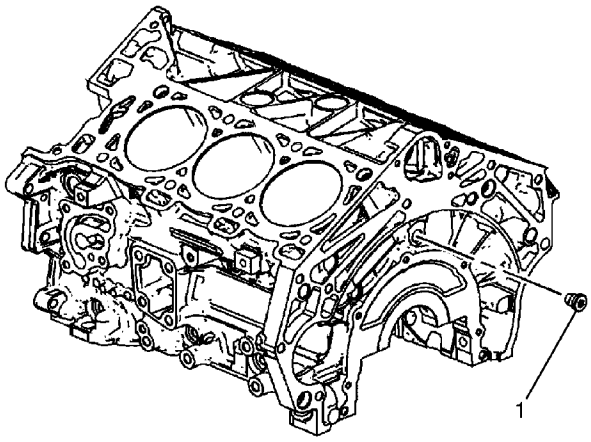
8. Apply thread sealant on the threads of the M20 left side oil gallery threaded plug (1).

Caution: Refer to Fastener Caution in the Preface section.

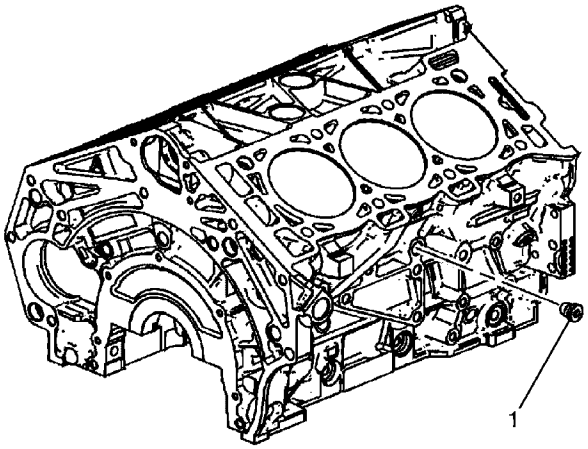
9. Install the M20 left side oil gallery threaded plug (1) and tighten to **31 N·m (23 lb ft)**.



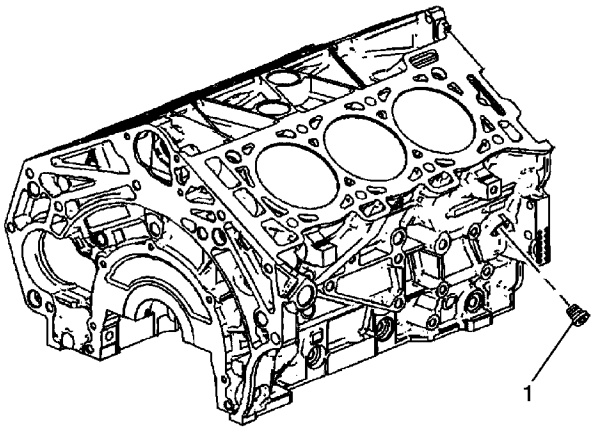
10. Apply thread sealant on the threads of the M14 left side coolant drain threaded plug (1).
11. Install the M14 left side coolant drain threaded plug (1) and tighten to **31 N·m (23 lb ft)**.



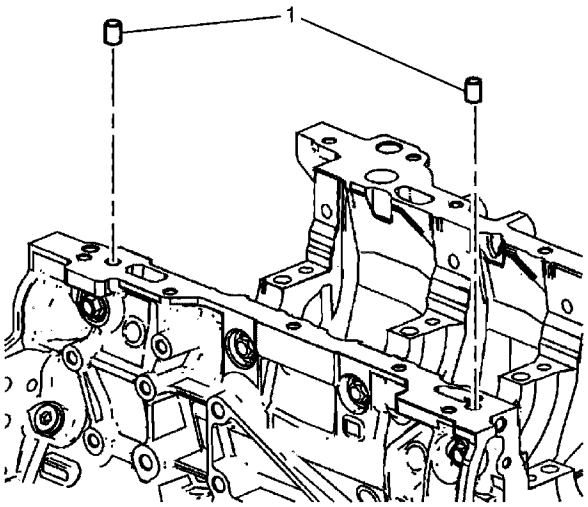
12. Apply thread sealant on the threads of the M14 rear oil gallery threaded plug (1).
13. Install the M14 rear oil gallery threaded plug (1) and tighten to **31 N·m (23 lb ft)**.



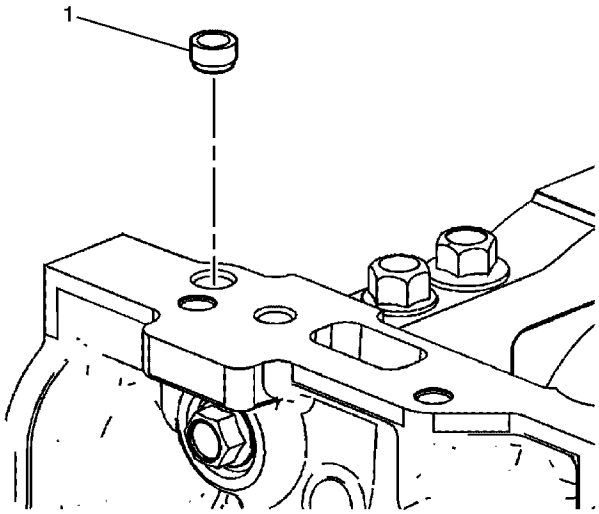
14. Apply thread sealant on the threads of the M14 right side coolant drain threaded plug (1).
15. Install the M14 right side coolant drain threaded plug (1) and tighten to **31 N·m (23 lb ft)**.



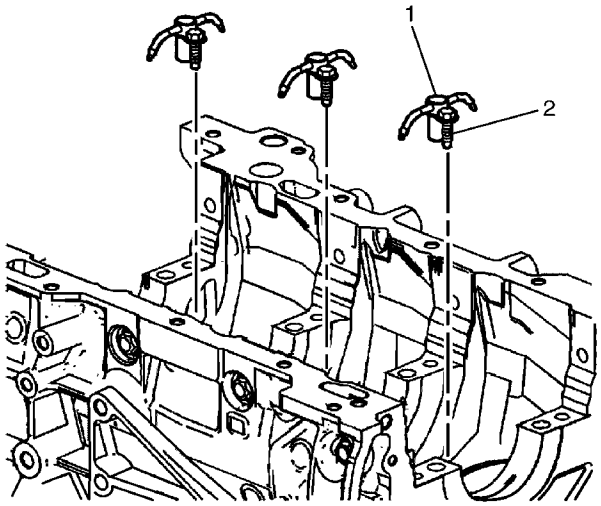
16. Apply thread sealant on the threads of the M14 right side oil gallery threaded plug (1).
17. Install the M14 right side oil gallery threaded plug (1) and tighten to **31 N·m (23 lb ft)**.



18. Install the cylinder block-to-oil pan alignment dowels (1).



19. Install the NEW right front oil pan rail oil gallery expansion plug (1).
20. Make sure the NEW right front oil pan rail oil gallery expansion plug (1) is installed to the correct depth.



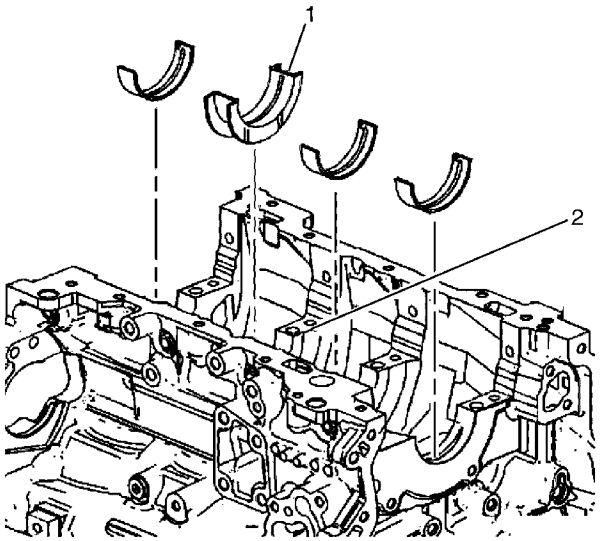
21. Install the oil jets (1).
22. Install the oil jet to cylinder block retaining bolts (2) and tighten to **10 N·m (89 lb in)**.

Crankshaft and Bearing Installation

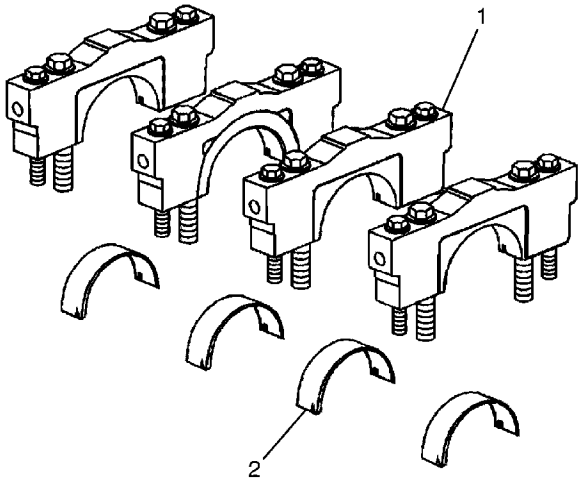
Crankshaft Bearing Installation Procedure

Note: If the crankshaft bearings have been used in a running engine, you must replace them with NEW crankshaft bearings for reassembly.

1. Clean the crankcase crank bore with a lint-free cloth.
2. Clean all the oil from the backside of new bearing halves.



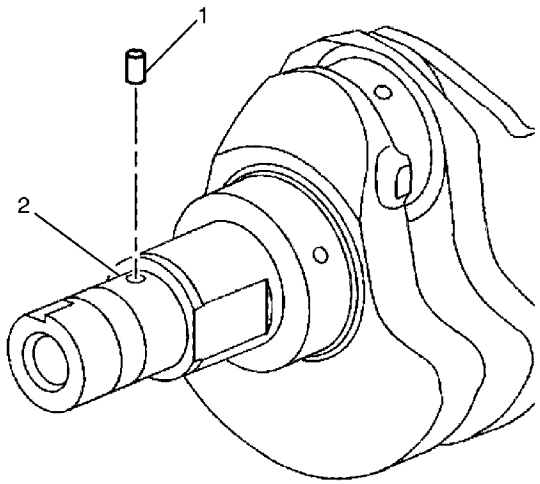
3. Install the new upper crankshaft bearings into position. The thrust bearing (1) belongs in the number 3 journal (2). Make sure that the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.



© 2010 General Motors Corporation. All rights reserved.

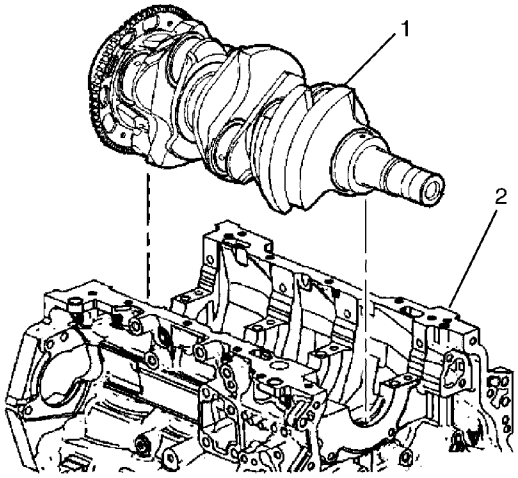
4. Install the new lower crankshaft bearings (2) into position in the crankshaft bearing caps (1). The lower crankshaft bearings (2) are identified by NO grooves or holes. The lower crankshaft bearings (2) must fit flush with the crankshaft bearing caps (1).

Crankshaft Installation Procedure



Notice: The crankshaft sprocket drive pin must be set to the proper depth. Installing the crankshaft sprocket drive pin too deep can lead to damage to the crankshaft sprocket and extensive engine damage.

1. If removed, install the crankshaft sprocket drive pin (1). Lightly tap the crankshaft sprocket drive pin (1) in place with a small soft face, bronze/plastic, hammer until it bottoms in the hole of the crankshaft (2).



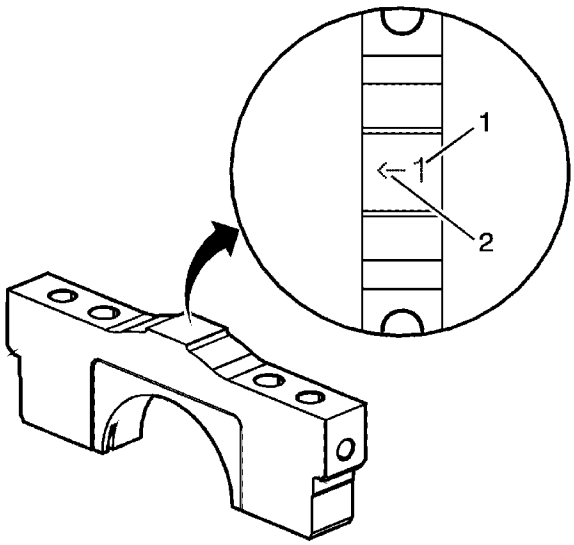
2. Gently lower the crankshaft (1) into position in the cylinder block (2).

Crankshaft Bearing Clearance Measurement Procedure

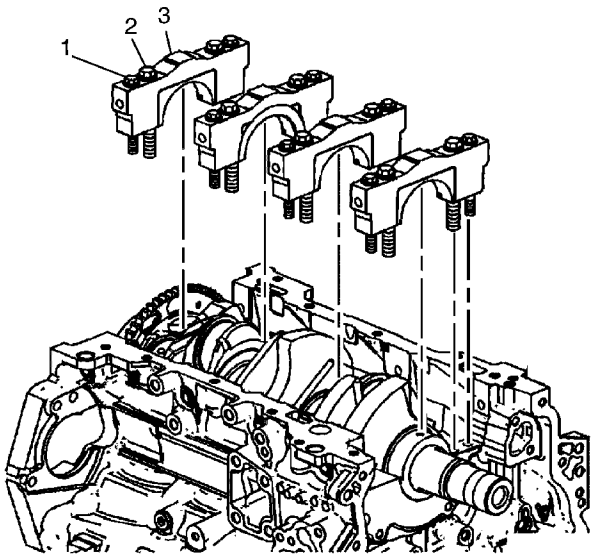
Special Tools

- *J 6125-1B* Slide Hammer Adapter
- *J 41818* Crankshaft Bearing Cap Remover
- *J 45059* Angle Meter

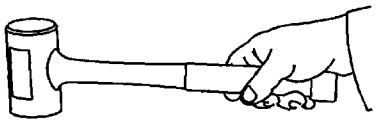
For equivalent regional tools, refer to Special Tools.

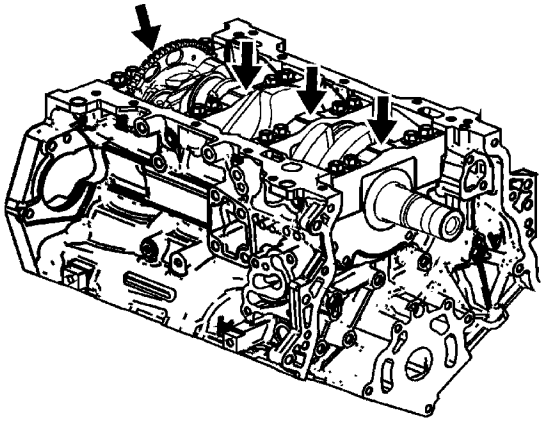


1. Place a length of fresh, room temperature plastic gauging material all the way across all the crankshaft bearing journals.
2. Identify the proper order of the crankshaft bearing caps. The crankshaft bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the cylinder block.

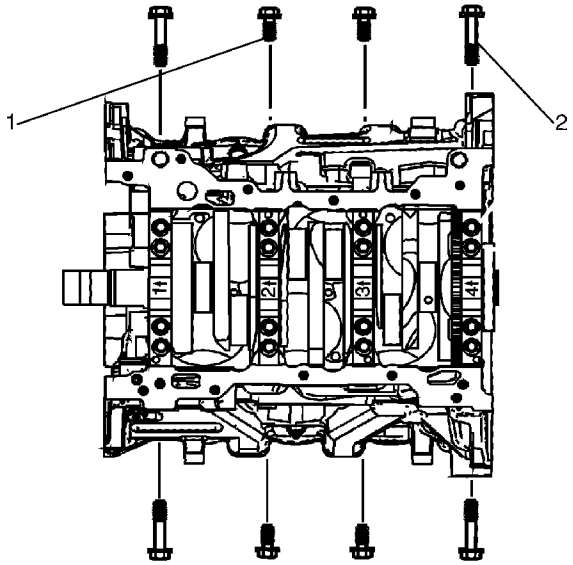


3. Install the crankshaft bearing caps (3).
4. Loosely install the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
5. Loosely install the original outer crankshaft bearing cap to cylinder block retaining bolts (2).



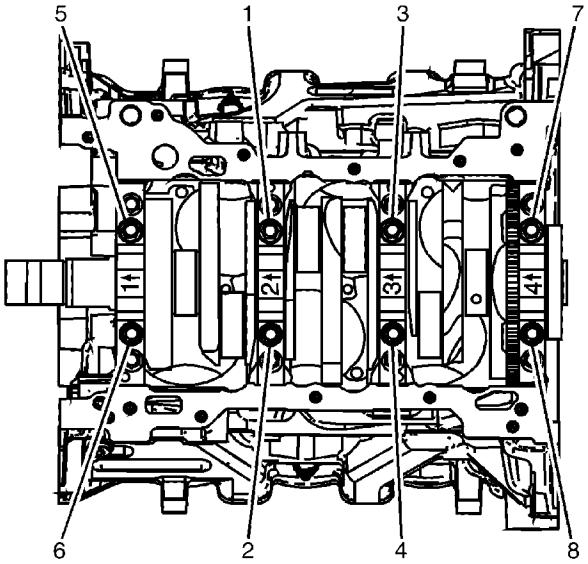


6. Tap the crankshaft bearing caps with a soft-faced hammer to help seat the crankshaft bearing caps.

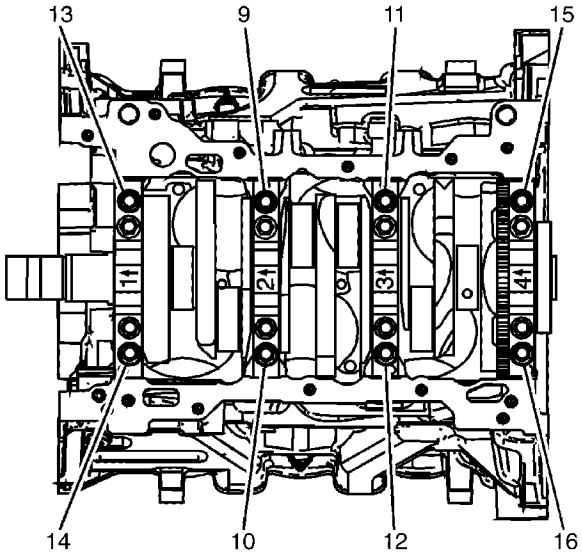


7. Loosely install the original short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
8. Loosely install the original long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).
9. Tighten the crankshaft bearing cap to cylinder block retaining bolts using the *J 45059* meter in the following sequence:

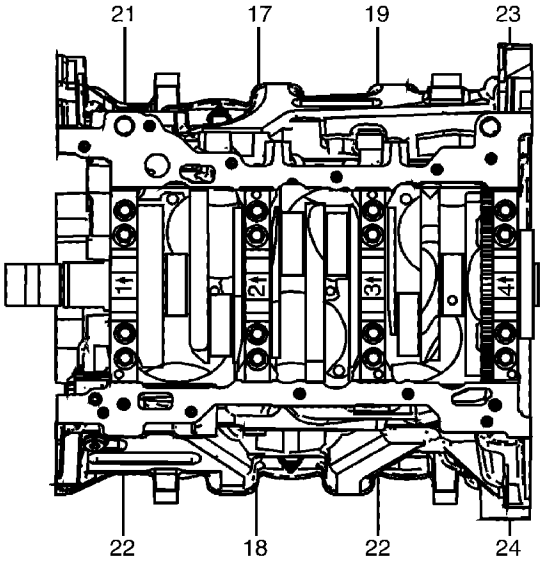
Caution: Refer to Fastener Caution in the Preface section.



10. Tighten the inboard crankshaft bearing cap to cylinder block retaining bolts (1-8) and tighten to **20 N·m (15 lb ft) plus 80 degrees**.



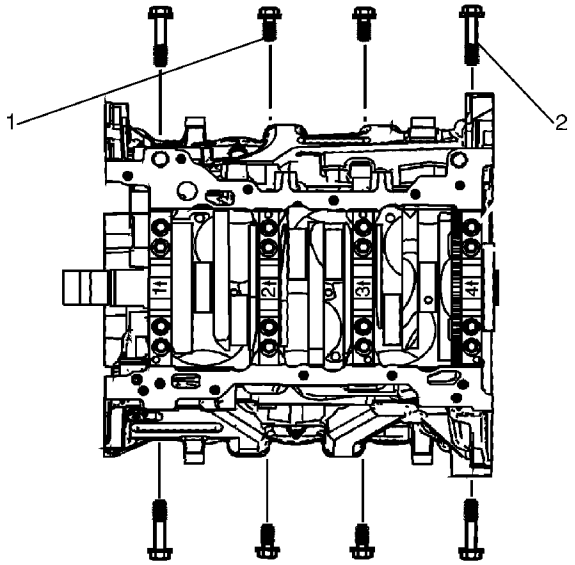
11. Tighten the outboard crankshaft bearing cap to cylinder block retaining bolts (9-16) and tighten to **15 N·m (11 lb ft) plus 110 degrees**.



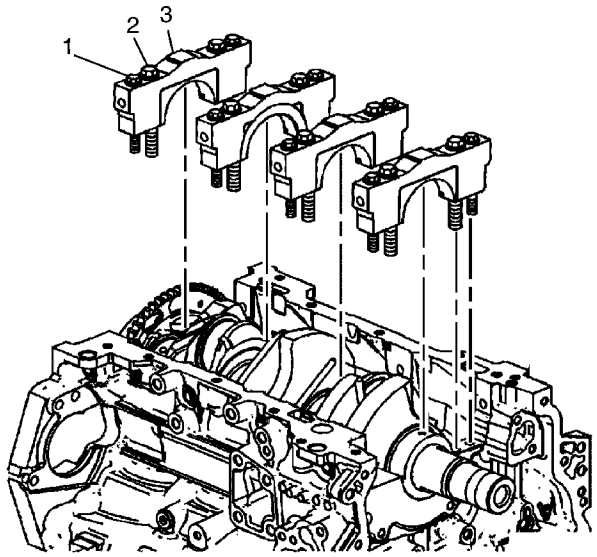
12. Tighten the short/inner crankshaft bearing cap to cylinder block retaining bolts (17-20) and tighten to **30 N·m (22 lb ft) plus 60 degrees**.
13. Tighten the long/outer crankshaft bearing cap to cylinder block retaining bolts (21-24) and tighten to **30 N·m (22 lb ft) plus 60 degrees**.

Note: DO NOT rotate the crankshaft.

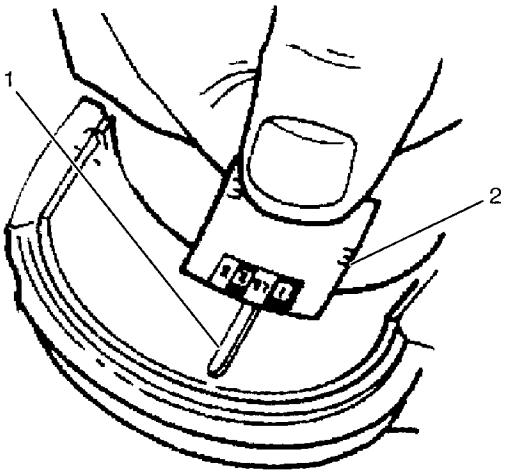
14. After reaching final torque, allow the assembly to sit for 2 minutes.



15. Remove the original short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
16. Remove the original long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).



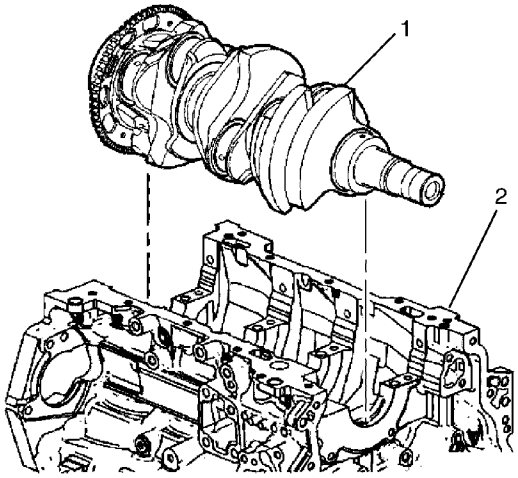
17. Remove the install the original outer crankshaft bearing cap to cylinder block retaining bolts (2).
18. Remove the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
19. Remove the crankshaft bearing caps (3) using the *J 6125-1B* adapter and *J 41818* remover



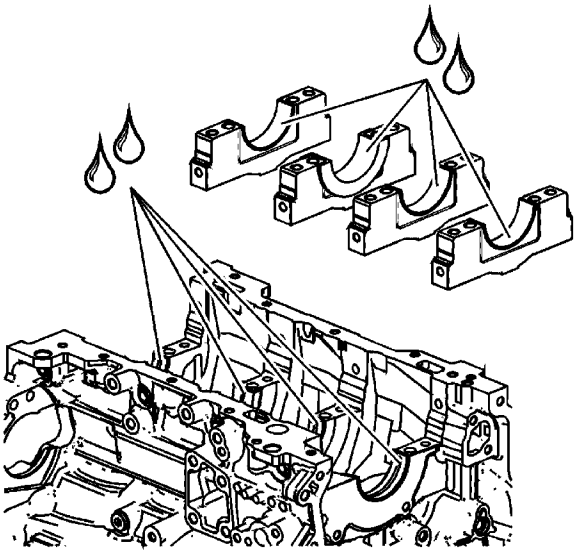
20. Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gauging material (1) at its widest point with the graduation on the gauging material container (2).

Note: The crankshaft bearings CAN be reused after checking the clearance if the bearings have never been used in a running engine.

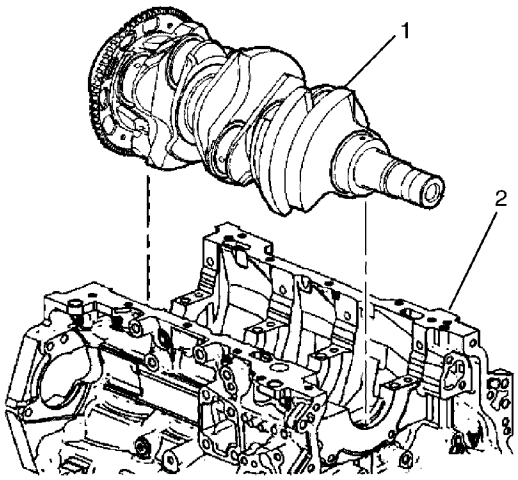
21. Compare your measurements with the engine mechanical specifications. Refer to Engine Mechanical Specifications. If the new bearings DO NOT provide the proper crankshaft to bearing clearance, inspect the following:
    21.1. Re-measure the crankshaft journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
    21.2. Re-measure the cylinder block crankshaft bearing bore diameter to ensure proper size. The cylinder block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.
22. Clean the plastic gauging material from the crankshaft bearing journals with a soft, lint-free cloth.



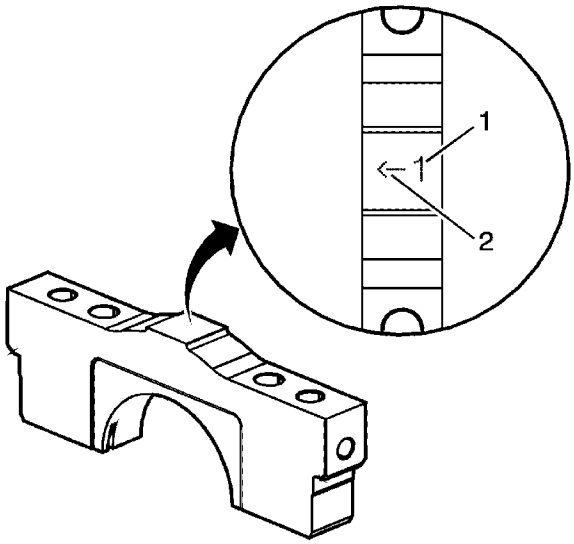
23. Lift the crankshaft (1) out of the cylinder block (2).



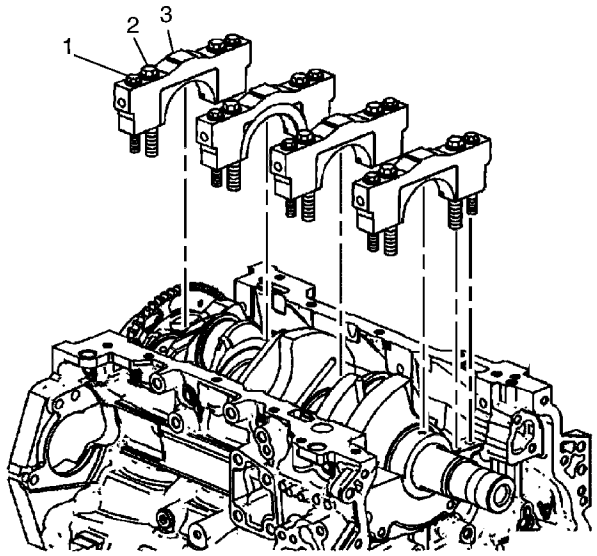
24. Apply a liberal amount of clean engine oil to the upper and lower bearing surfaces.



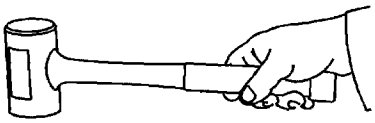
25. Gently lower the crankshaft (1) into position in the cylinder block (2).

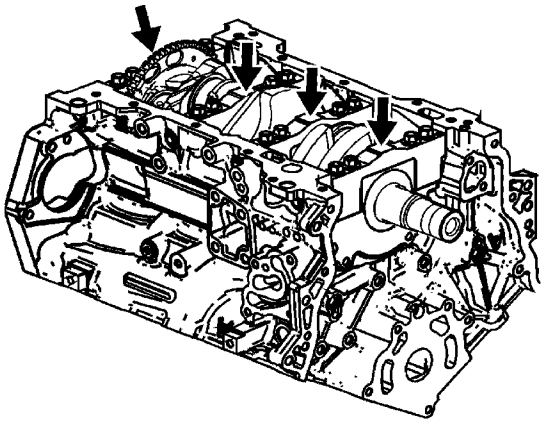


26. Identify the proper order of the crankshaft bearing caps. The crankshaft bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the cylinder block.

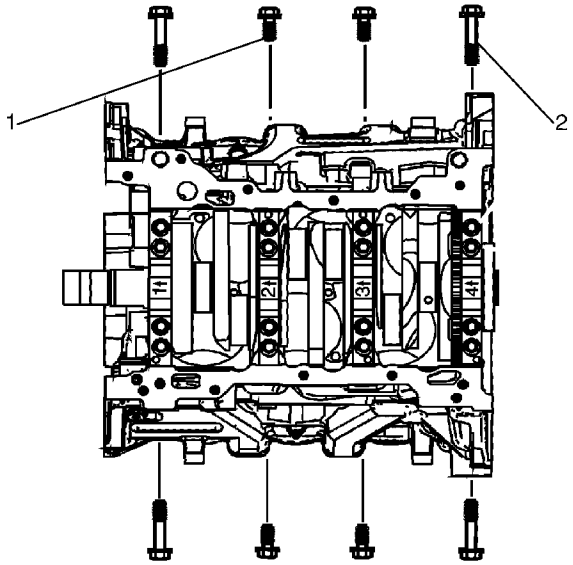


27. Install the crankshaft bearing caps (3).
28. Loosely install the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
29. Loosely install the NEW outer crankshaft bearing cap to cylinder block retaining bolts (2).



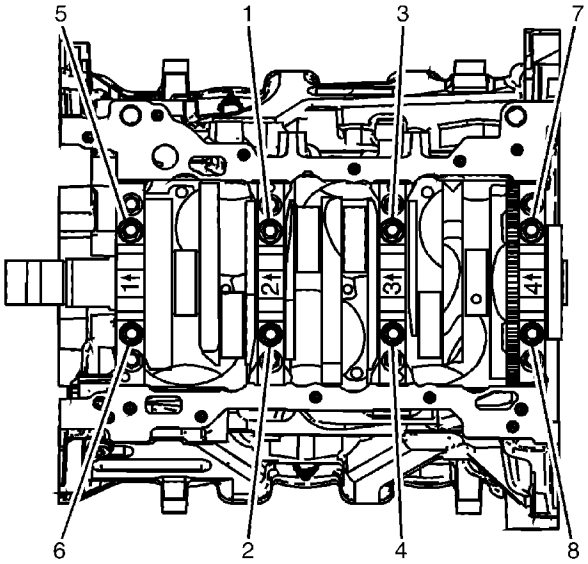


30. Tap the crankshaft bearing caps with a soft-faced hammer to help seat the crankshaft bearing caps.

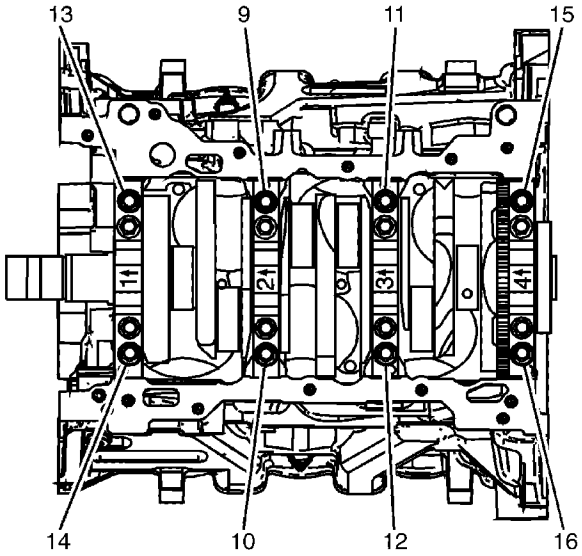


Note: The side main cap bolts originally have a sealant on the flange of the bolt head. NEW bolts must be used. If NEW bolts are not used, oil can leak from the crankcase past the bolts.

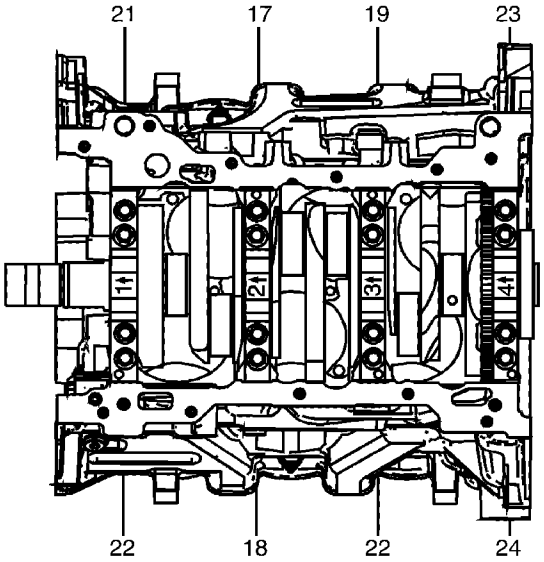
31. Loosely install the NEW short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
32. Loosely install the NEW long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).
33. Tighten the crankshaft bearing cap to cylinder block retaining bolts using the *J 45059* meter in the following sequence:



34. Tighten the inboard crankshaft bearing cap to cylinder block retaining bolts (1-8) and tighten to **20 N·m (15 lb ft) plus 80 degrees**.



35. Tighten the outboard crankshaft bearing cap to cylinder block retaining bolts (9-16) and tighten to **15 N·m (11 lb ft) plus 110 degrees**.



36. Tighten the short/inner crankshaft bearing cap to cylinder block retaining bolts (17-20) and tighten to **30 N·m (22 lb ft) plus 60 degrees**.
37. Tighten the long/outer crankshaft bearing cap to cylinder block retaining bolts (21-24) and tighten to **30 N·m (22 lb ft) plus 60 degrees**.
38. Make sure that the crankshaft turns without binding or noise.

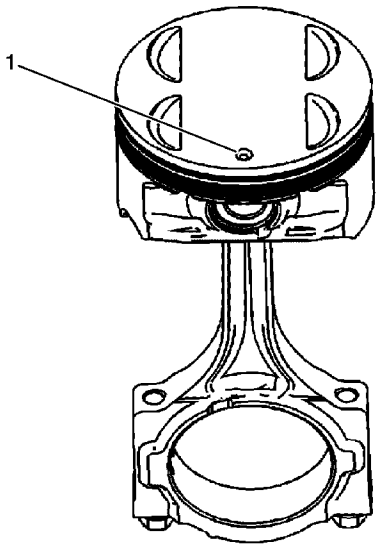
Piston, Connecting Rod, and Bearing Installation

Special Tools

- *EN 46111* Crankshaft Rotation Socket
- *EN 46121* Connecting Rod Guide Pin Set
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.

Piston and Connecting Rod Assembly Procedure

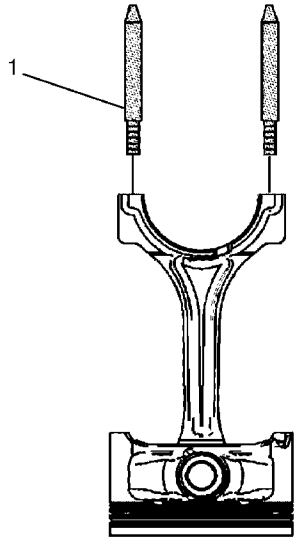


1. Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil.

   Note: The piston is directional and must be installed in the cylinder block in the correct direction.

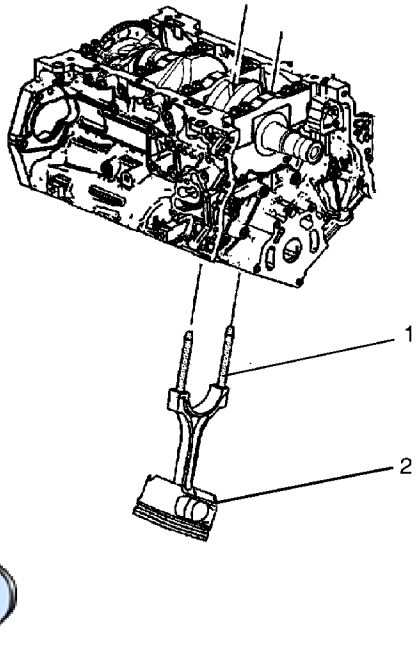
2. Select the correctly numbered piston/connecting rod assembly for the cylinder. A dot (1) showing proper piston orientation is located on the top of the piston.

© 2010 General Motors Corporation. All rights reserved.



Note: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

3. Install the connecting rod bearing into the connecting rod.
4. Install the *EN 46121* guide pin set (1) into the connecting rod bolt holes.
5. Compress the piston rings using a commercially available ring compressor.

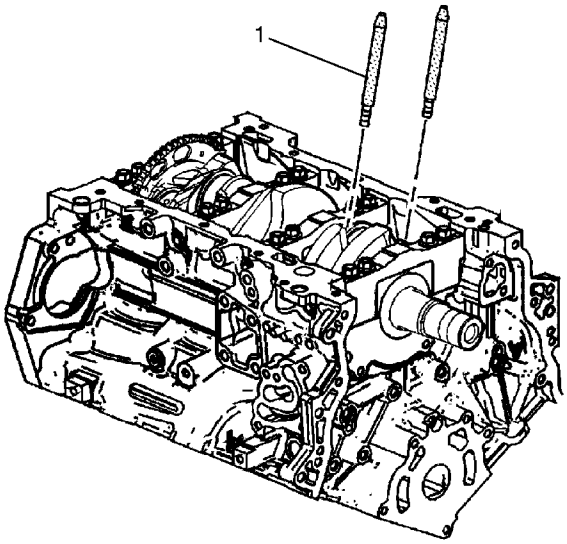


Note: Extreme care must be used when installing the piston (2) and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore, the oil jets, or the crankshaft surfaces.

6. Using both hands, slowly guide the piston (2) and connecting rod assembly into the cylinder

from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.

7. When the ring compressor contacts the deck surface, gently tap the piston (2) into the cylinder using the handle end of a dead-blow hammer. Guide the connecting rod onto the crankshaft bearing journal using the *EN 46121* guide pin set (1) while gently tapping the piston (2) into the cylinder with a soft-blow hammer.



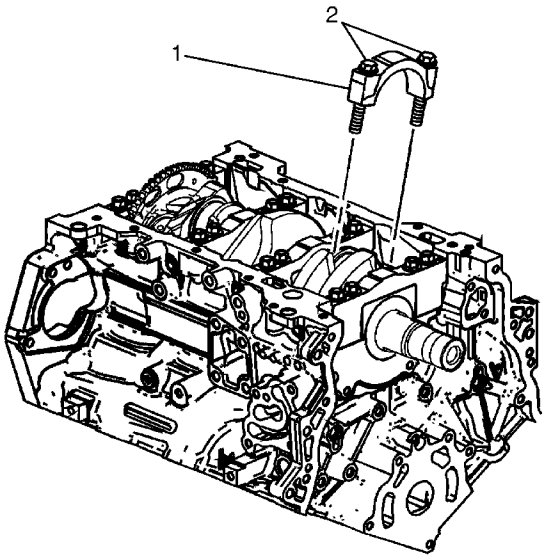
8. Remove the *EN 46121* guide pin set (1) from the connecting rod bolt holes.

Connecting Rod Bearing Clearance Measurement Procedure - Using Plastic Gaging

Note: Connecting rod bearings that have been run in an engine should NEVER be reused.

Note: Prior to final assembly it is the clearance of the new connecting rod bearings must be checked.

1. Place a length of fresh, room temperature plastic gauging material all the way across the connecting rod bearing journal.
2. Install the connecting rod bearing into the connecting rod cap.



Note: The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.

3. Install the connecting rod end cap (1) on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the connecting rod.

Caution: Refer to Fastener Caution in the Preface section.

Caution: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

Note: Reuse the old connecting rod bolts (2) ONLY for measuring the connecting rod bearing clearance.

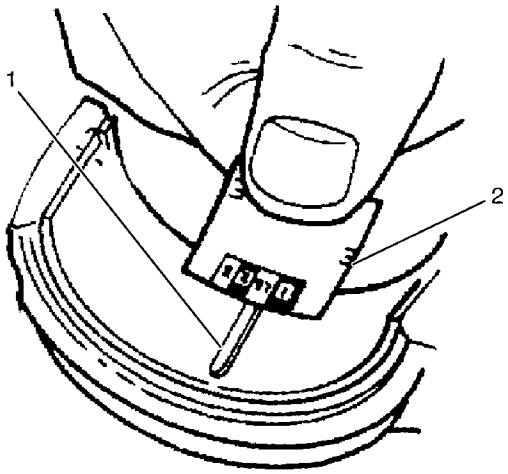
4. Install the connecting rod bolts (2) into the connecting rod cap (1) and tighten bolts to **30 N·m (22 lb ft)**.
5. Loosen the connecting rod bolts (2) until the torque reading is zero.
6. Re-tighten the connecting rod bolts (2).
   6.1. First Pass

   Tighten the connecting rod bolts to **25 N·m (18 lb ft).**

   6.2. Final Pass

   Tighten the connecting rod bolts an additional **110 degrees** using the *J 45059* meter .

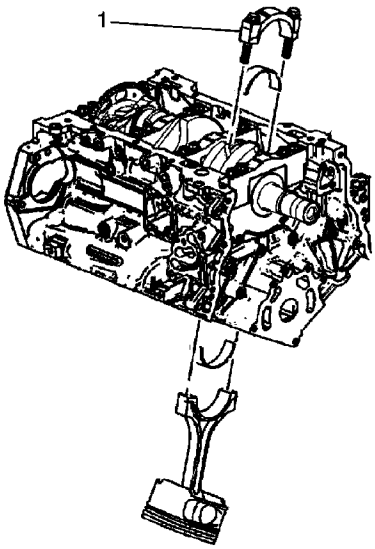
7. Allow the assembly to sit for at least 2 minutes.
8. Remove the connecting rod cap bolts (2).
9. Remove the connecting rod cap (1).



10. Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gauging material (1) at its widest point with the graduation on the gauging material container (2).
11. Compare your measurements with the engine mechanical specifications. Refer to Engine Mechanical Specifications. If the new bearings DO NOT provide the proper crankshaft to connecting rod bearing clearance, inspect the following:
    11.1. Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft connecting rod journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
    11.2. Re-measure the connecting rod bearing bore diameter to ensure proper size. The connecting rod is not machinable and the connecting rod must be replaced if out of specification.
12. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

Connecting Rod Final Assembly Procedure

1. Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
2. Apply a liberal amount of clean engine oil to the crankshaft connecting rod bearing journal.
3. Guide the connecting rod to the crankshaft connecting rod journal.
4. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.



Caution: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

Note: DO NOT reuse the old connecting rod bolts.

5. Install the NEW connecting rod bolts into the connecting rod cap (1) and tighten the NEW bolts to **30 N·m (22 lb ft)**.
6. Loosen the connecting rod bolts until the torque reading is zero.
7. Re-tighten the connecting rod bolts.
   7.1. First Pass

   Tighten the connecting rod bolts to **25 N·m (18 lb ft).**.

   7.2. Final Pass

   Tighten the connecting rod bolts an additional **110 degrees** using the *J 45059* meter .

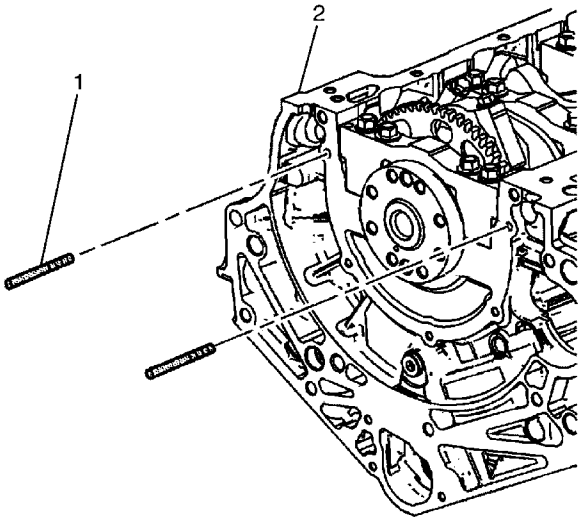
8. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the cylinder block.
9. Repeat these procedures for the remaining piston/connecting rod assemblies using the *EN 46111* socket in order to rotate the crankshaft.

Crankshaft Rear Oil Seal and Housing Installation

Special Tools

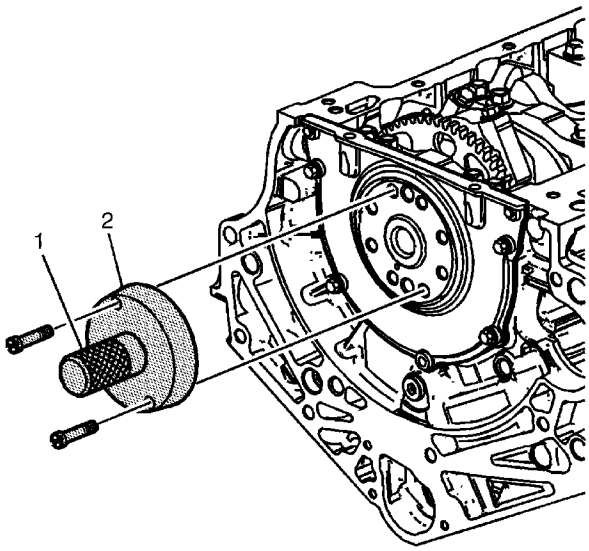
- *EN 46109* Guide Pin Set
- *EN 47839* Crankshaft Rear Oil Seal Installation Tool
- *J 42183* Handle

For equivalent regional tools, refer to Special Tools.

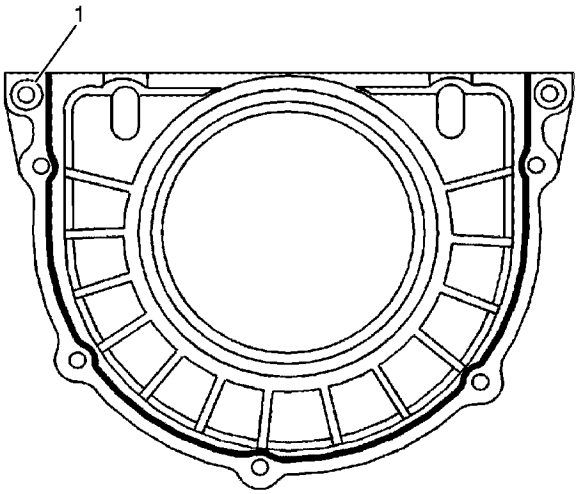


1. Install the 6 mm (0.236 in) guides from the *EN 46109* guide pin set (1) into the 2 crankshaft rear oil seal housing corner bolt holes of the cylinder block (2).

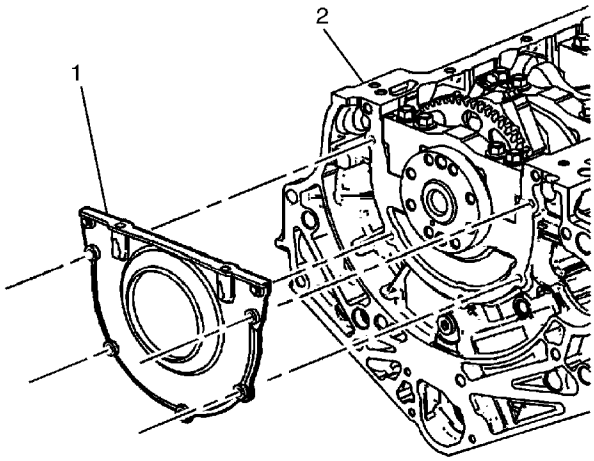
© 2010 General Motors Corporation. All rights reserved.



2. Install the *J 42183* handle (1) with the *EN 47839* installation tool (2) onto the rear of the crankshaft flange.

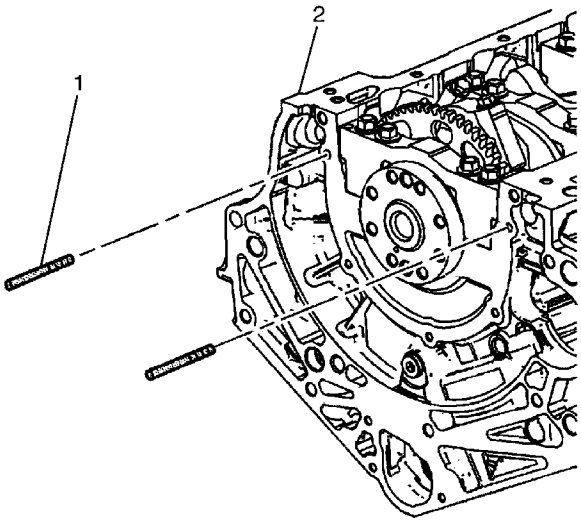


3. Place a 3 mm (0.118 in) bead of RTV sealant (1) to the NEW crankshaft rear oil seal housing as shown.



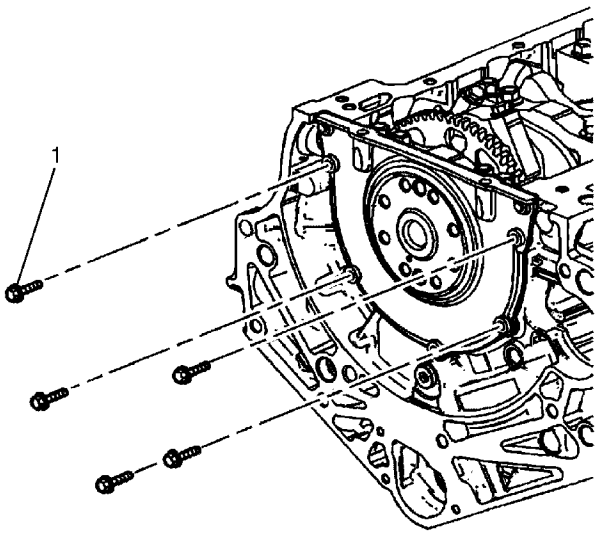
Note: DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.

4. Install the crankshaft rear oil seal housing (1) to the cylinder block (2).

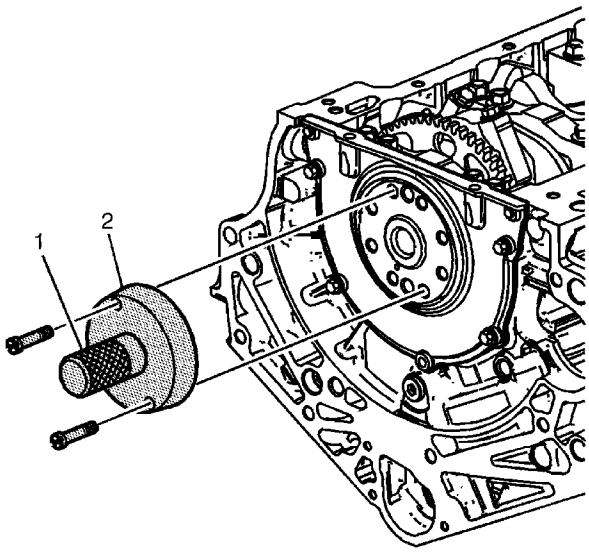


5. Remove the *EN 46109* guide pin set mm (0.236 in) guides (1) from the cylinder block (2).

Caution: Refer to Fastener Caution in the Preface section.

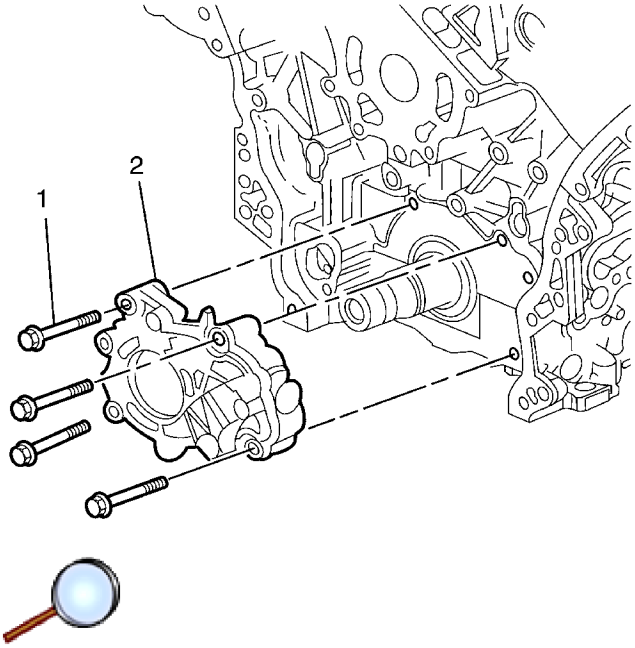


6. Install the crankshaft rear oil seal housing to cylinder block retaining bolts (1) and tighten to **10 N·m (89 lb in)**.



7. Remove the *J 42183* handle (1) and *EN 47839* installation tool (2) from the crankshaft flange.

Oil Pump Installation



1. Align the oil pump gerotor with the crankshaft flats and install the oil pump (2).
2. Align the oil pump (2) body mounting holes.

Caution: Refer to Fastener Caution in the Preface section.

3. Install the oil pump to cylinder block retaining bolts (1) and tighten to 23 N·m (17 lb ft).

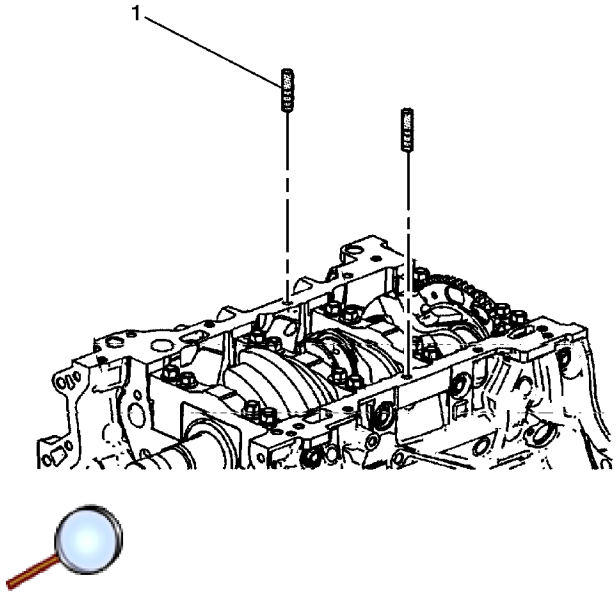
© 2010 General Motors Corporation. All rights reserved.

Oil Pan Installation

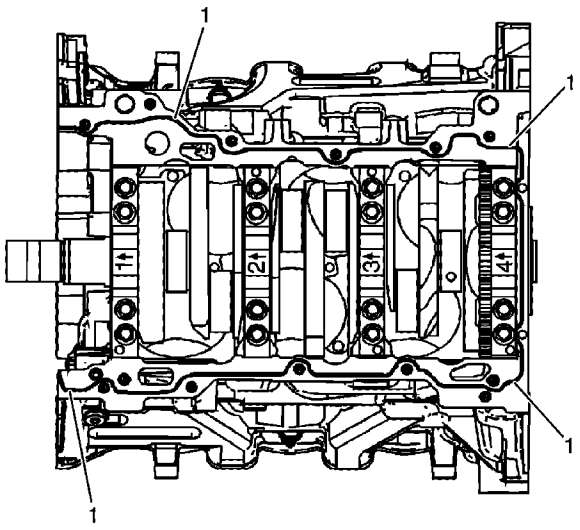
Special Tools

EN 46109 Guide Pin Set

For equivalent regional tools, refer to Special Tools.

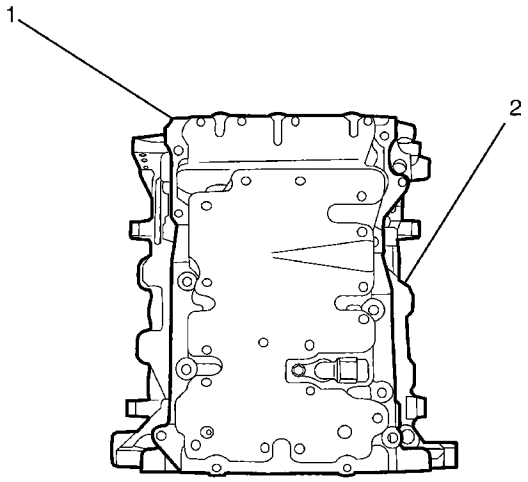


1. Install the 8 mm (0.315 in) guides from the *EN 46109* guide pin set (1) into the center oil pan rail bolt hole on each side of the cylinder block.

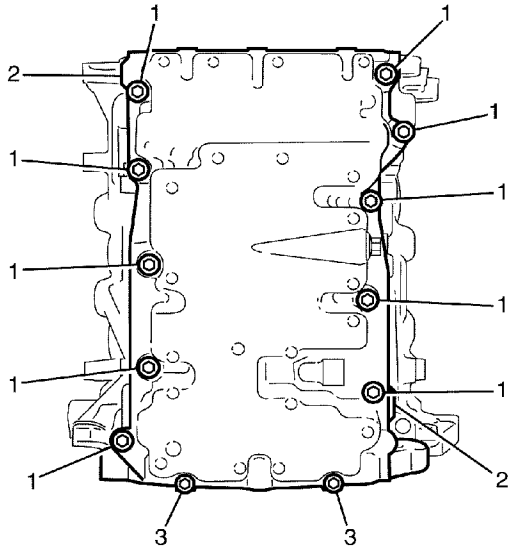


© 2010 General Motors Corporation. All rights reserved.

2. Place a 3 mm (0.118 in) bead of RTV sealant (1) on the block pan rail and the crankshaft rear oil seal housing.

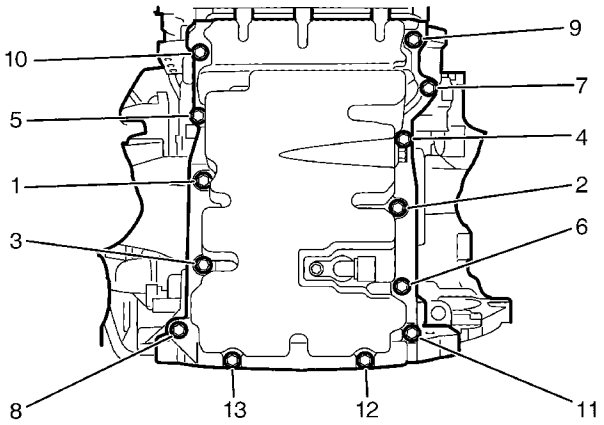


3. Position the oil pan (1) onto the block (2).
4. Remove the *EN 46109* guide pin set mm (0.315 in) guides from the cylinder block.



5. Loosely install the M8 oil pan to cylinder block retaining bolts (1).
6. Loosely install the M6 oil pan to crankshaft rear oil seal housing retaining bolts (3).

Caution: Refer to Fastener Caution in the Preface section.



7. Install and tighten the M8 oil pan to cylinder block retaining bolts (1-11) and the M6 oil pan to crankshaft rear oil seal housing retaining bolts (12, 13) in the sequence shown.
   - Tighten the M8 bolts (1-11) to **23 N·m (17 lb ft)**.
   - Tighten the M6 bolts (12, 13) to **10 N·m (89 lb in)**.

Cylinder Head Installation - Right Side

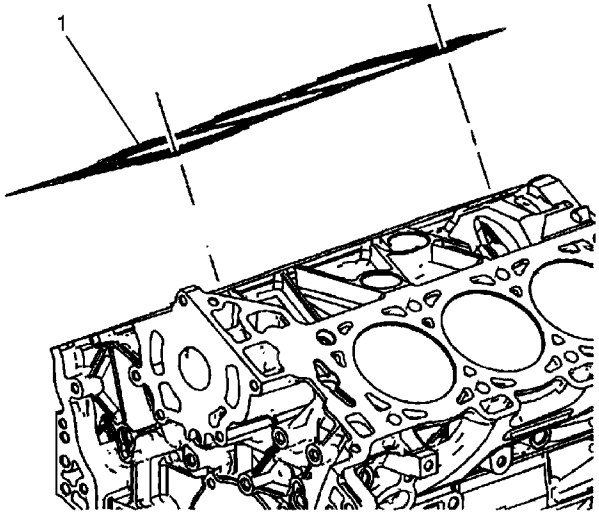
Special Tools

- *EN 46111* Crankshaft Rotation Socket
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.

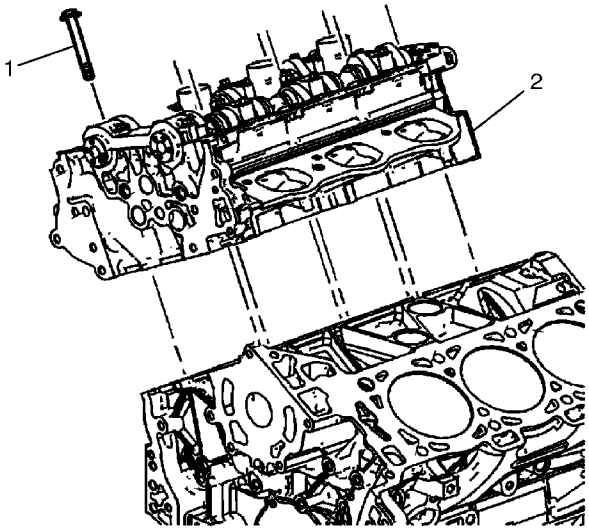
Note: Make sure that the crankshaft is in the timing drive assembly position using the *EN 46111* socket .

1. Make sure the cylinder head locating pins are securely mounted in the cylinder block deck face.



2. Install a NEW right cylinder head gasket (1) using the deck face locating pins for retention.

© 2010 General Motors Corporation. All rights reserved.



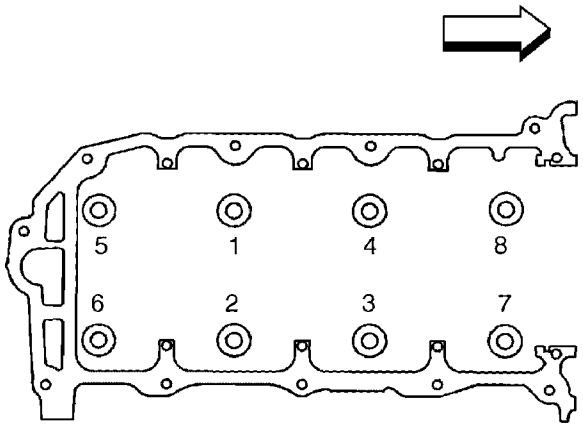
3. Align the right cylinder head (2) with the deck face locating pins.
4. Place the right cylinder head (2) in position on the deck face.

Note: DO NOT allow oil on the cylinder head bolt bosses.

Note: DO NOT reuse the old M11 cylinder head bolts.

5. Loosely install the NEW M11 and M8 cylinder head to cylinder block retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.



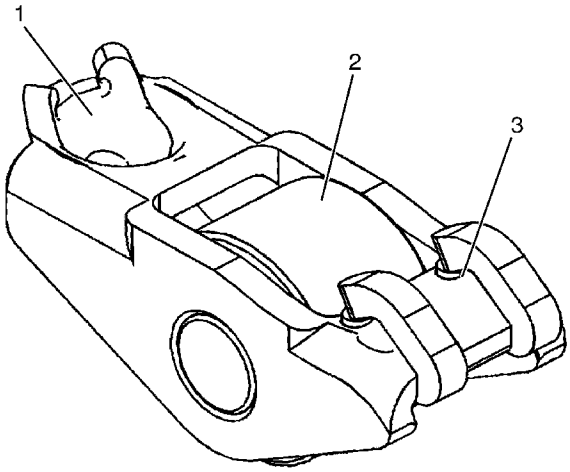
6. Tighten the cylinder head to cylinder block retaining bolts in the sequence shown.

7. Tighten the M11 cylinder head to cylinder block retaining bolts a first pass in sequence to **45 N·m (33 lb ft)**.
   7.1. Back off the M11 cylinder head to cylinder block retaining bolts 120 degrees using the *J 45059* meter .
   7.2. Tighten the M11 cylinder head to cylinder block retaining bolts a second pass in sequence to **30 N·m (22 lb ft)**.
   7.3. Tighten the M11 cylinder head to cylinder block retaining bolts a third pass in sequence an additional 150 degrees using the *J 45059* meter .
8. Install the 2 front M8 left cylinder head to cylinder block retaining bolts (9, 10).

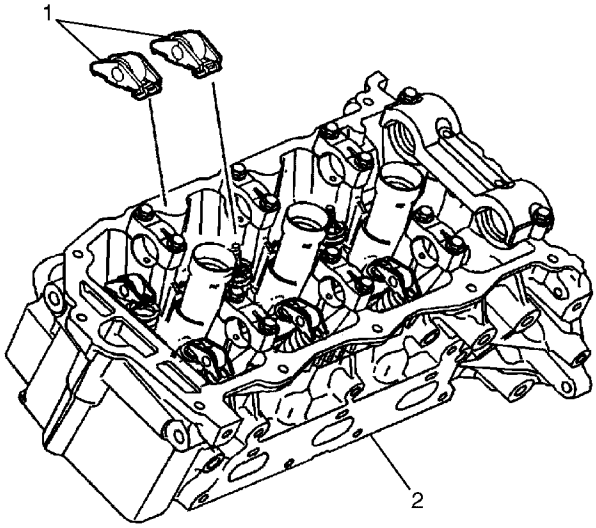
   Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a first pass to **15 N·m (11 lb ft)**.

   Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a second pass in sequence an additional 60 degrees using the *J 45059* meter .

Valve Rocker Arm Installation - Right Side



1. Apply a liberal amount of commercially available camshaft/lifter prelube to the pivot pocket (1), roller (2) and valve slot (3) areas of the valve rocker arms.



Important: The valve rocker arms (1) must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the valve rocker arms (1) are being reused you must put them back in their original location.

© 2010 General Motors Corporation. All rights reserved.

2. Place the valve rocker arms (1) in position on the valve tip and Stationary Hydraulic Lash Adjuster (SHLA).
3. The rounded head end of the valve rocker arms (1) go on the SHLA while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

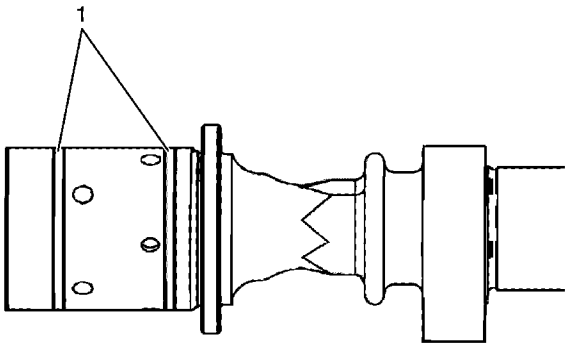
Camshaft Installation - Right Side

Special Tools

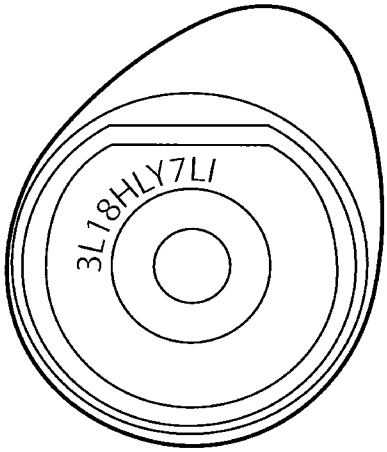
EN 46111 Crankshaft Rotation Socket

For equivalent regional tools, refer to Special Tools.

1. Ensure that the crankshaft is in the stage one timing drive assembly position using the *EN 46111* socket . Refer to Camshaft Timing Drive Chain Alignment Diagram.



2. Make sure that the camshaft sealing rings (1) are in place in the camshaft grooves.



© 2010 General Motors Corporation. All rights reserved.

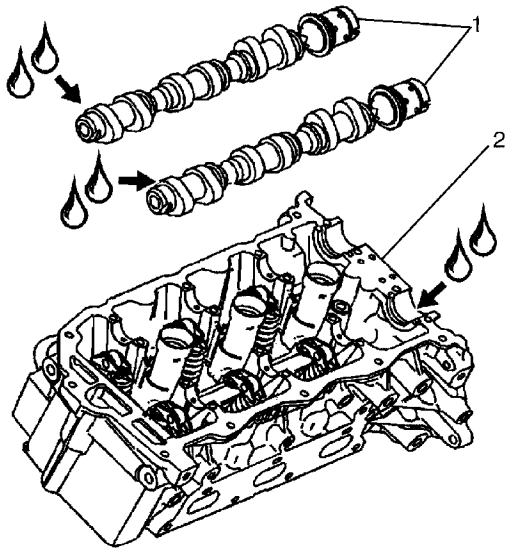
3. Select the proper camshaft for the particular installation location. ID markings are on the rear end of each camshaft. The ID markings are defined as follows:
   3.1. The first five digits refer to the date and time of production.

   Example: 3L18H.

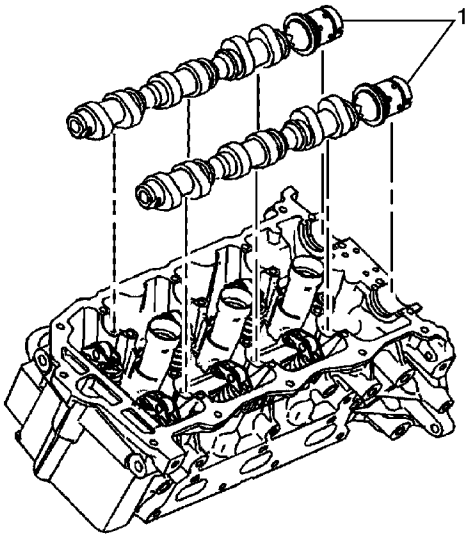
   3.2. Digits 6-9 refer to the production code.

   LY7 - High Feature V6

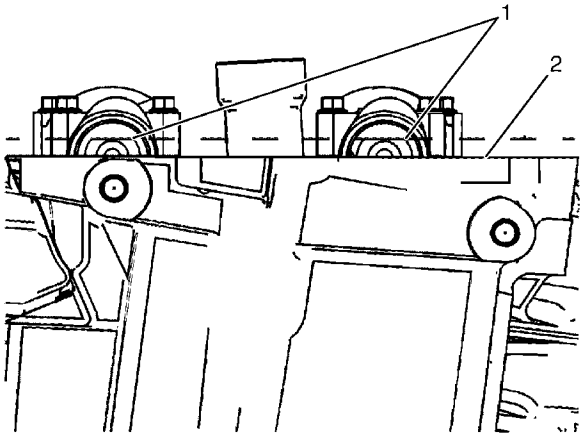
   3.3. The last two digits refer to the camshaft position.
   - Example:
   - LI - Left Bank Intake
   - LE - Left Bank Exhaust
   - RI - Right Bank Intake
   - RE - Right Bank Exhaust



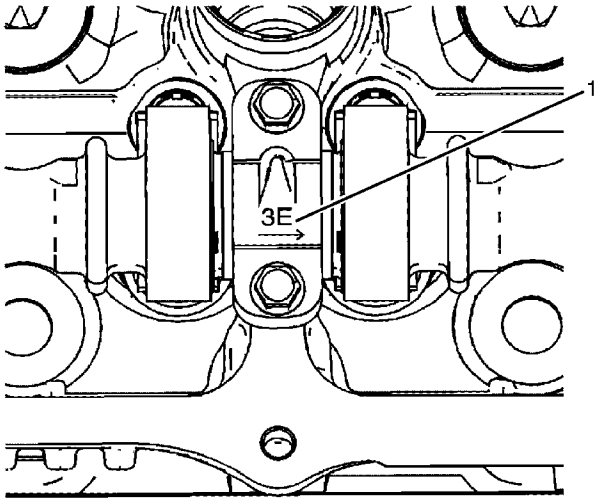
4. Apply a liberal amount of engine oil to the camshaft (1) journals and the right cylinder head (2) camshaft carriers.



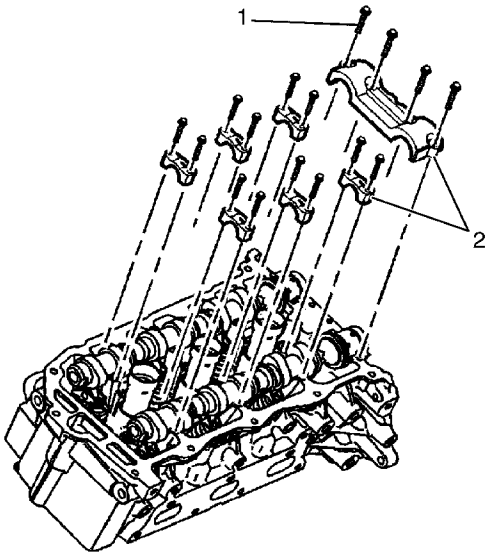
5. Place the camshafts (1) in position in the right cylinder head (2).



6. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the right cylinder head camshaft cover rail.

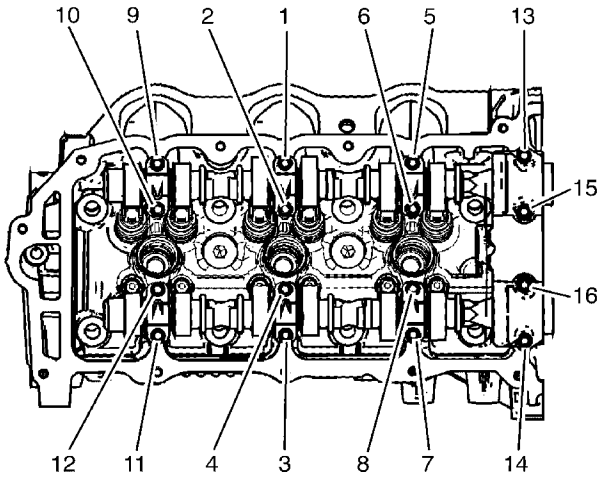


7. Observe the markings on the right cylinder head camshaft bearing caps. Each bearing cap is marked (1) in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number 1, 3, 5 indicates the cylinder position from the front of the cylinder block.
8. Apply a liberal amount of engine oil to the camshaft bearing caps.



9. Install the camshaft bearing thrust cap (2) in the first journal of the right cylinder head.
10. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
11. Hand start all the camshaft bearing cap to cylinder head retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.



12. Tighten the camshaft bearing cap to cylinder head retaining bolts in the sequence shown and tighten to **10 N·m (89 lb in)**.
13. Loosen the center intake camshaft bearing cap to cylinder head retaining bolts (1, 2) and the center exhaust camshaft bearing cap to cylinder head retaining bolts (3, 4).
14. Retighten the center camshaft bearing cap to cylinder head retaining bolts (1, 2, 3, 4) to **10 N·m (89 lb in)**.

Cylinder Head Installation - Left Side

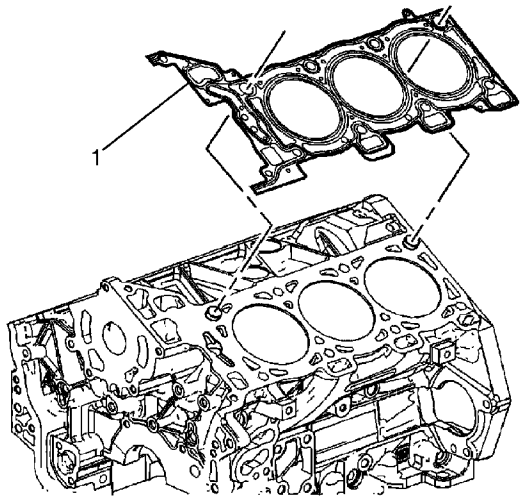
Special Tools

- *EN 46111* Crankshaft Rotation Socket
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.

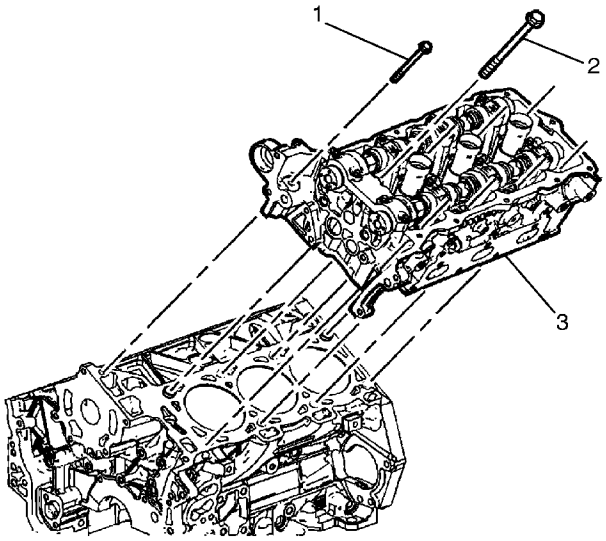
Note: Make sure that the crankshaft is in the timing drive assembly position using the *EN 46111* socket .

1. Make sure the cylinder head locating pins are securely mounted in the cylinder block deck face.



2. Install a NEW left cylinder head gasket (1) using the deck face locating pins for retention.

© 2010 General Motors Corporation. All rights reserved.



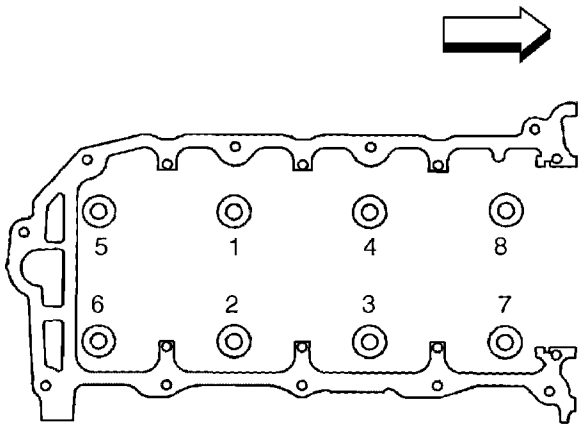
3. Align the left cylinder head (3) with the deck face locating pins.
4. Place the left cylinder head (3) in position on the deck face.

Note: DO NOT allow oil on the cylinder head bolt bosses.

Note: DO NOT reuse the old M11 cylinder head bolts.

5. Loosely install the NEW M11 cylinder head to cylinder block retaining bolts (2).
6. Loosely install the NEW M8 front cylinder head to cylinder block retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.



7. Tighten the cylinder head to cylinder block retaining bolts in the sequence shown.

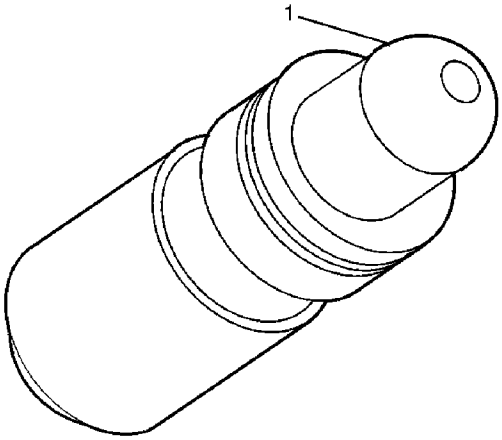
   Tighten the M11 cylinder head to cylinder block retaining bolts a first pass in sequence to **45 N·m (33 lb ft)**.

   7.1. Back off the M11 cylinder head to cylinder block retaining bolts 120 degrees using the *J 45059* meter .
   7.2. Tighten the M11 cylinder head to cylinder block retaining bolts a second pass in sequence to **30 N·m (22 lb ft)**.
   7.3. Tighten the M11 cylinder head to cylinder block retaining bolts a third pass in sequence an additional 150 degrees using the *J 45059* meter J 45059.
8. Install the 2 front M8 left cylinder head to cylinder block retaining bolts (9, 10).

   Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a first pass to **15 N·m (11 lb ft)**.

   Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a second pass in sequence an additional 60 degrees using the *J 45059* meter .

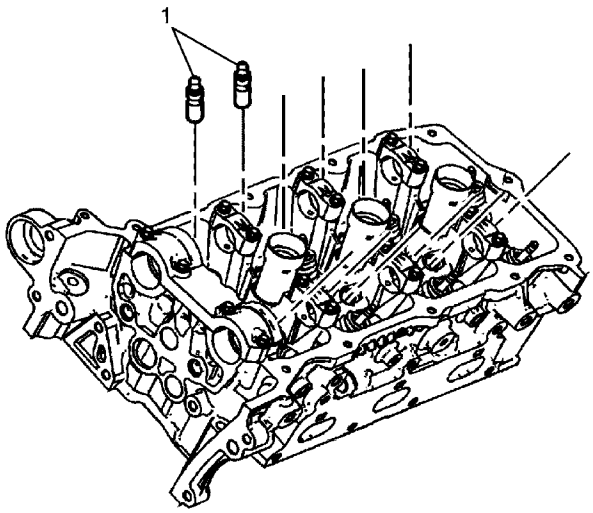
Valve Lifter Installation - Left Side



Important: DO NOT stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

Important: DO NOT allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

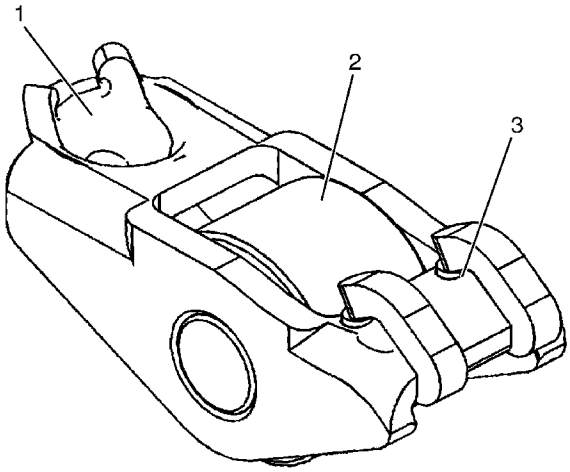
1. Fill the Stationary Hydraulic Lash Adjuster (SHLA) with clean engine oil. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil.



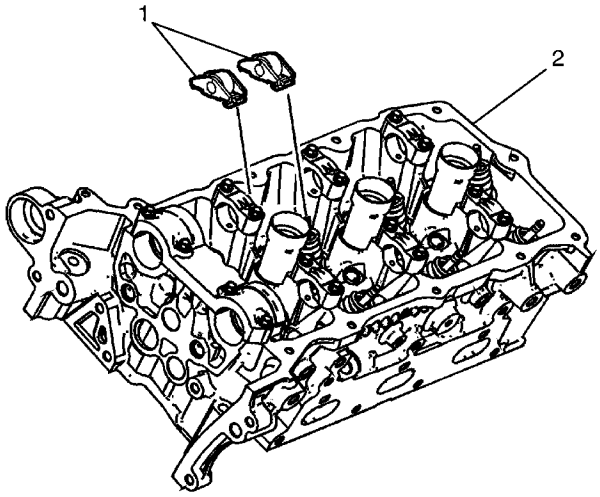
© 2010 General Motors Corporation. All rights reserved.

3. Install the SHLAs (1).
4. Apply a liberal amount of commercially available camshaft/lifter prelube to the SHLA (1) pivot spheres.

Valve Rocker Arm Installation - Left Side



1. Apply a liberal amount of commercially available camshaft/lifter prelube to the pivot pocket (1), roller (2) and valve slot (3) areas of the valve rocker arms.



Important: The valve rocker arms (1) must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the valve rocker arms (1) are being reused you must put them back in their original location.

© 2010 General Motors Corporation. All rights reserved.

2. Place the valve rocker arms (1) in position on the valve tip and Stationary Hydraulic Lash Adjuster (SHLA).
3. The rounded head end of the valve rocker arms (1) go on the SHLA while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

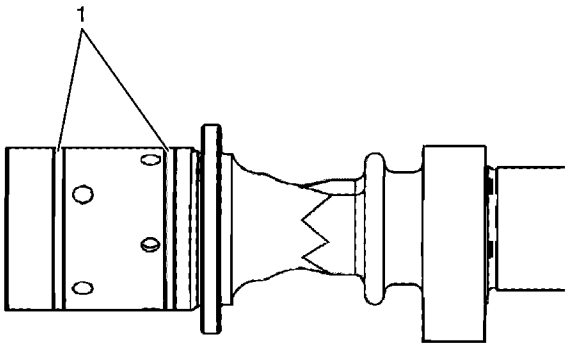
Camshaft Installation - Left Side

Special Tools

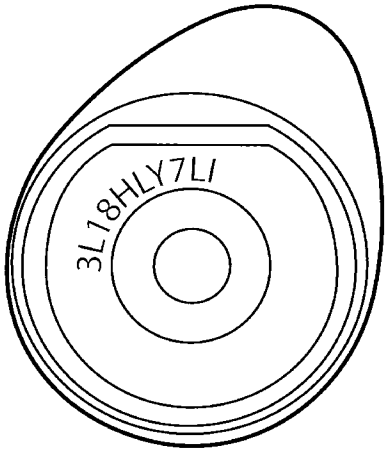
EN 46111 Crankshaft Rotation Socket

For equivalent regional tools, refer to Special Tools.

1. Ensure that the crankshaft is in the stage one timing drive assembly position using the *EN 46111* socket . Refer to Camshaft Timing Drive Chain Alignment Diagram.



2. Make sure that the camshaft sealing rings (1) are in place in the camshaft grooves.



© 2010 General Motors Corporation. All rights reserved.

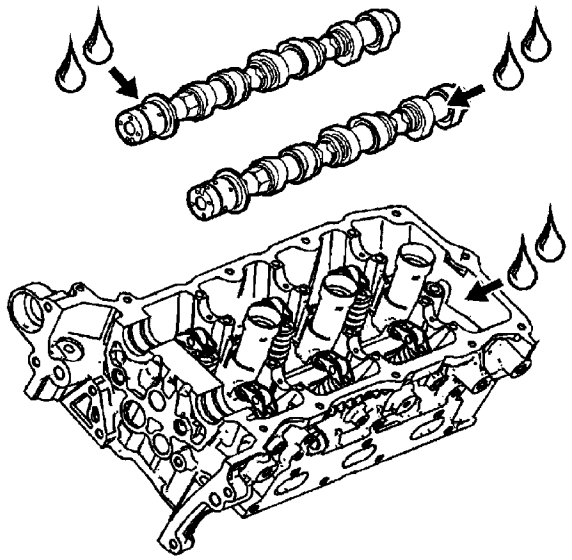
3. Select the proper camshaft for the particular installation location. ID markings are on the rear end of each camshaft. The ID markings are defined as follows:
   3.1. The first five digits refer to the date and time of production.

   Example: 3L18H.

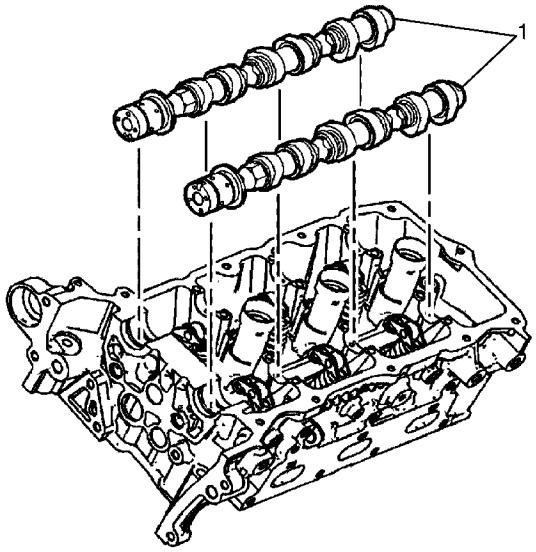
   3.2. Digits 6-9 refer to the production code.

   LY7 - High Feature V6

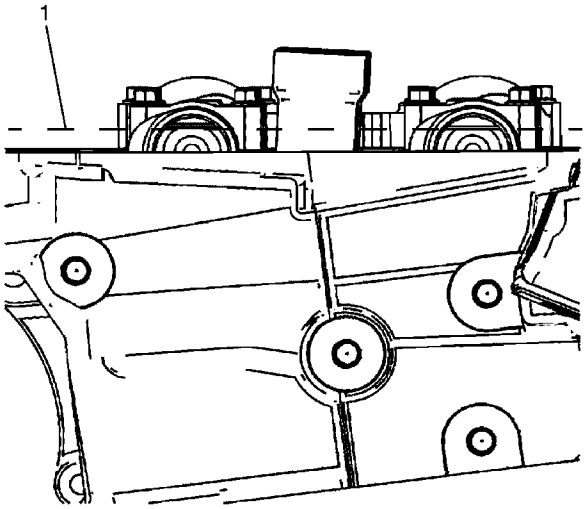
   3.3. The last two digits refer to the camshaft position.
   - Example:
   - LI - Left Bank Intake
   - LE - Left Bank Exhaust
   - RI - Right Bank Intake
   - RE - Right Bank Exhaust



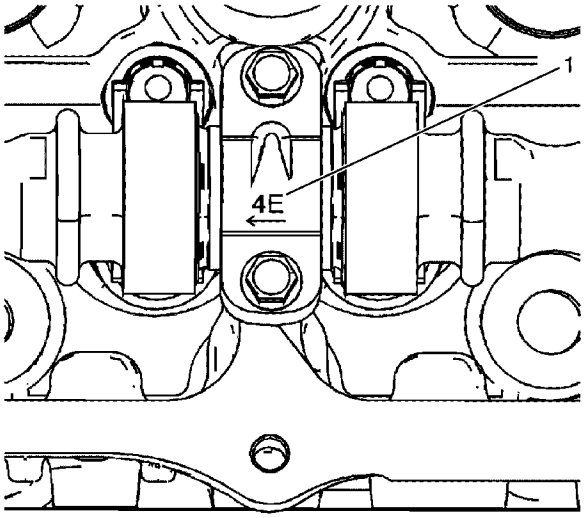
4. Apply a liberal amount of engine oil to the camshaft (1) journals and the left cylinder head (2) camshaft carriers.



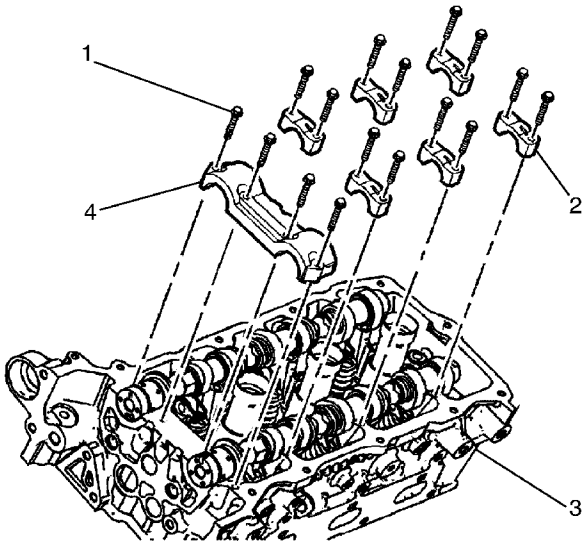
5. Place the camshafts (1) in position in the left cylinder head (2).



6. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the left cylinder head camshaft cover rail.

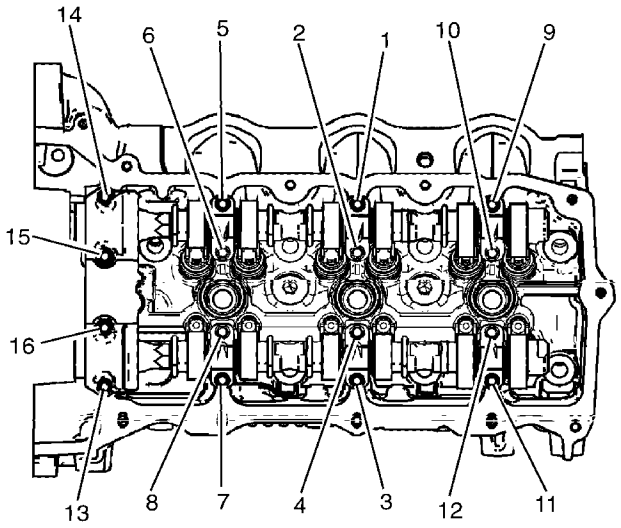


7. Observe the markings on the left cylinder head camshaft bearing caps. Each bearing cap is marked (1) in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number 1, 3, 5 indicates the cylinder position from the front of the cylinder block.
8. Apply a liberal amount of engine oil to the camshaft bearing caps.



9. Install the camshaft bearing thrust cap (4) in the first journal of the right cylinder head (3).
10. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head (3).
11. Hand start all the camshaft bearing cap to cylinder head retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.

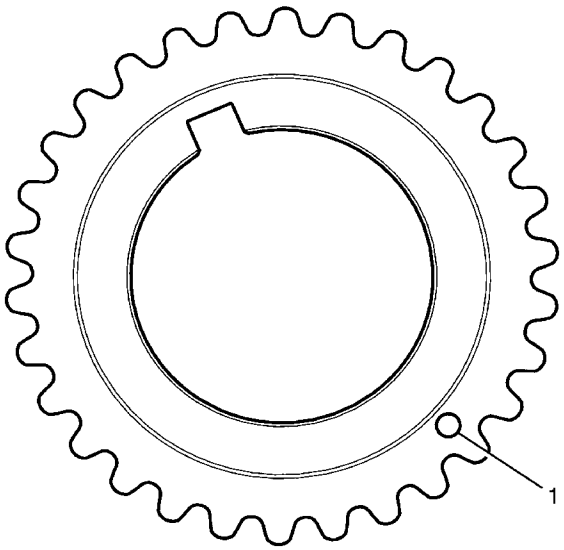


12. Tighten the camshaft bearing cap to cylinder head retaining bolts in the sequence shown to **10 N·m (89 lb in)**.
13. Loosen the center intake camshaft bearing cap to cylinder head retaining bolts (1, 2) and the center exhaust camshaft bearing cap to cylinder head retaining bolts (3, 4).
14. Retighten the center camshaft bearing cap to cylinder head retaining bolts (1, 2, 3, 4) to **10 N·m (89 lb in)**.

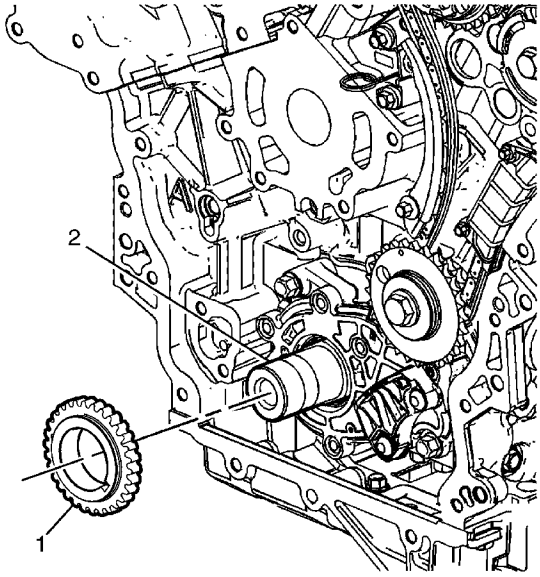
Crankshaft Sprocket Installation

Tools Required

EN 46111 Crankshaft Rotation Socket



1. Make sure the crankshaft sprocket is installed with the timing mark (1) visible.

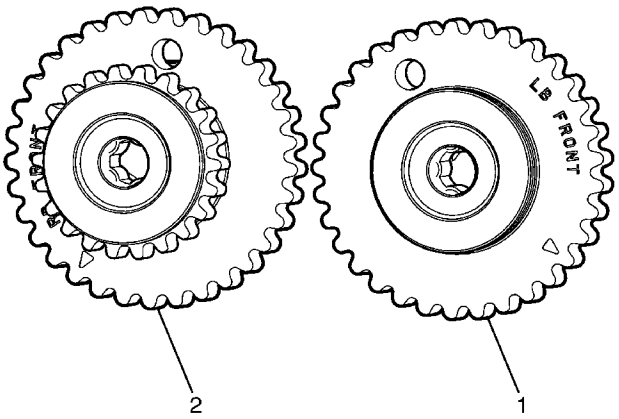


2. Install the crankshaft sprocket (1) on to the nose of the crankshaft (2).
3. Align the keyway in the crankshaft sprocket (1) with the key in the crankshaft (2).

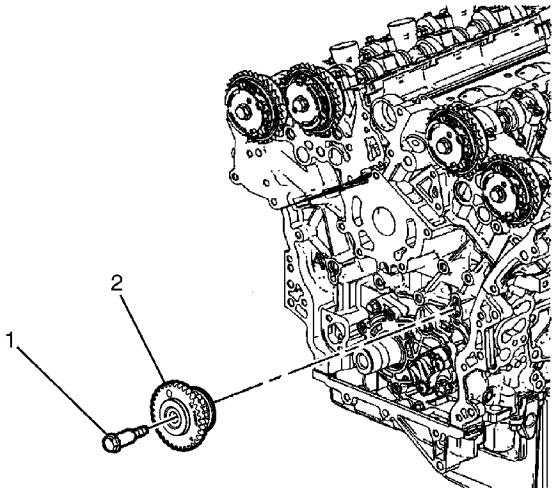
© 2010 General Motors Corporation. All rights reserved.

4. Slide the crankshaft sprocket on the crankshaft (2) nose until the crankshaft sprocket (1) contacts the step in the crankshaft (2).
5. If necessary, align the crankshaft sprocket to the stage one timing drive assembly position using the EN 46111 . Refer to Camshaft Timing Drive Chain Alignment Diagram.

Camshaft Intermediate Drive Chain Idler Installation - Left Side



1. Make sure that the left camshaft intermediate drive chain idler (1) is being installed. The recessed hub (2) and the larger sprocket of the left camshaft intermediate drive chain idler is installed outward. The raised hub and the smaller sprocket of the left camshaft intermediate drive chain idler is installed towards the cylinder block.



2. Install the left camshaft intermediate drive chain idler (2).

© 2010 General Motors Corporation. All rights reserved.

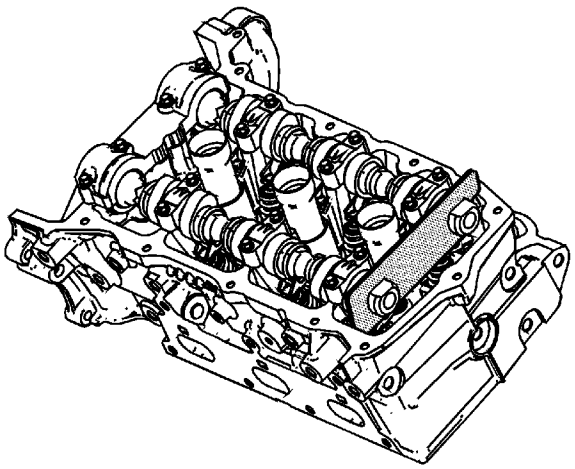
Caution: Refer to Fastener Caution in the Preface section.

3. Install the camshaft intermediate drive chain idler to cylinder block retaining bolt (1) and tighten to **58 N·m (43 lb ft)**.

Secondary Camshaft Drive Chain Installation - Left Side (LY7 or LP1)

Special Tools

- EN-48383 Camshaft Retaining Tools
- EN-48589 Crankshaft Rotation Socket



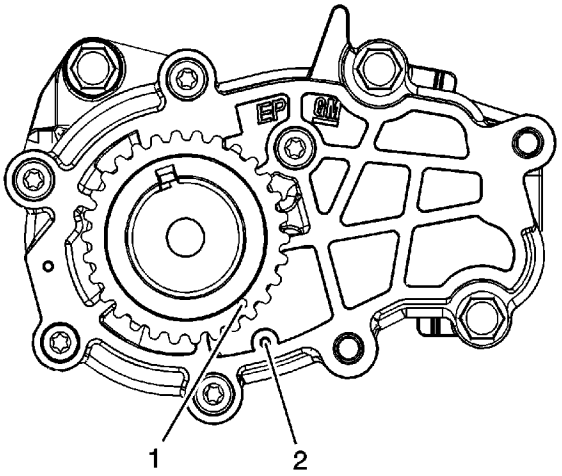
Important: There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the EN-48383 .

1. Install the EN 48383-1 onto the rear of the left camshafts.

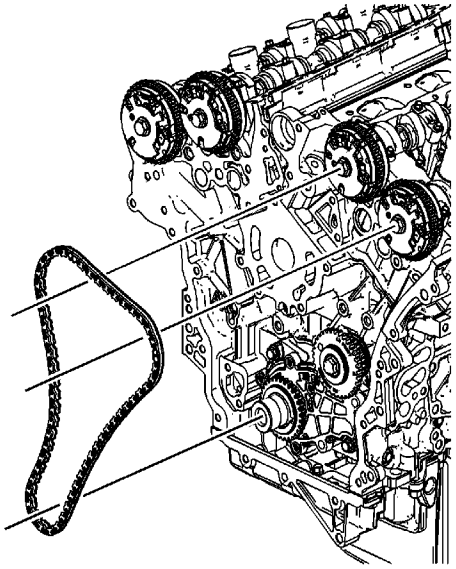
   Important: All camshafts must be locked in place before installation of any camshaft drive chains.

2. Ensure that the EN 48383-1 is fully seated onto the camshafts.

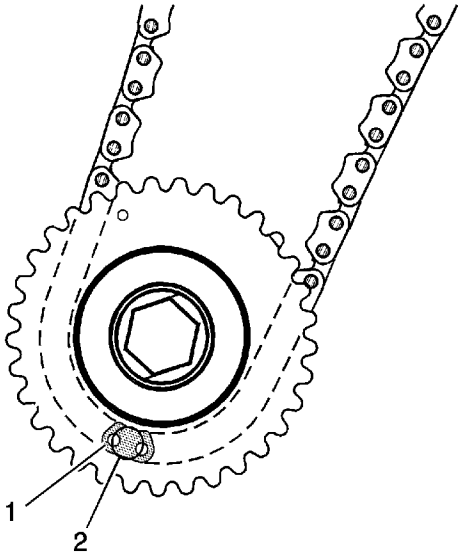
© 2010 General Motors Corporation. All rights reserved.



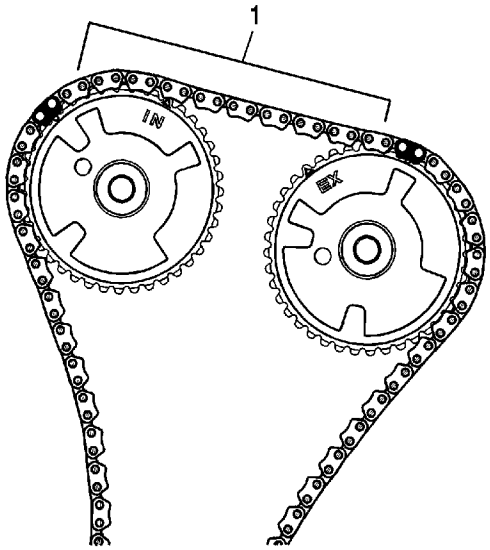
3. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (1) aligned to the stage one timing mark on the oil pump cover (2) using the EN-48589 . Refer to Camshaft Timing Drive Chain Alignment Diagram.



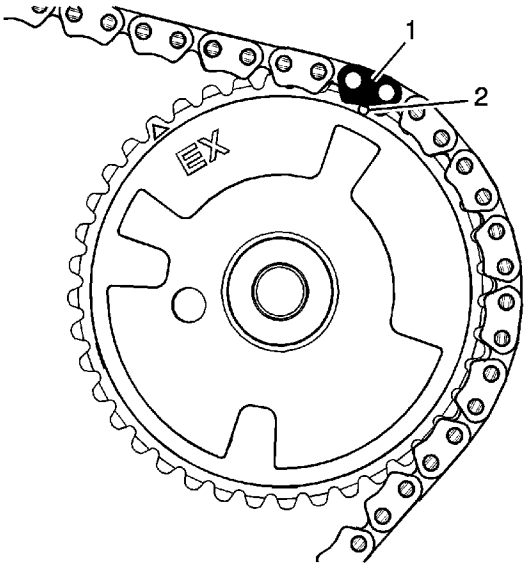
4. Install the left secondary camshaft drive chain.



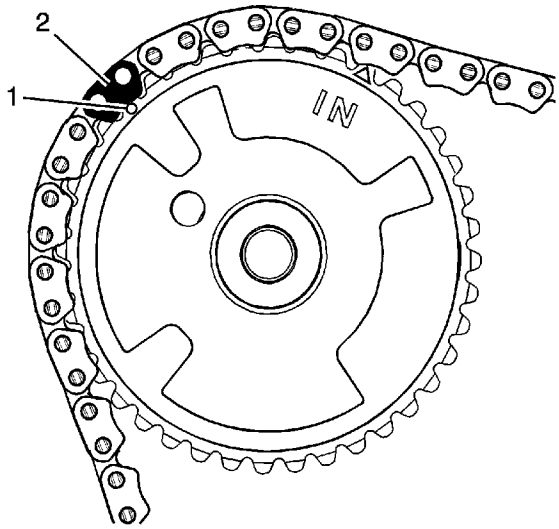
5. Place the left secondary camshaft drive chain around the inner sprocket of the left camshaft intermediate drive chain idler with the timing camshaft drive chain link (1) aligned to the alignment access hole (2) made in the left camshaft intermediate drive chain idler outer sprocket.



6. Wrap the secondary camshaft drive chain around both left actuator drive sprockets.
7. Ensure there are 10 links (1) between the timing camshaft drive chain links for the camshaft position actuator sprockets.

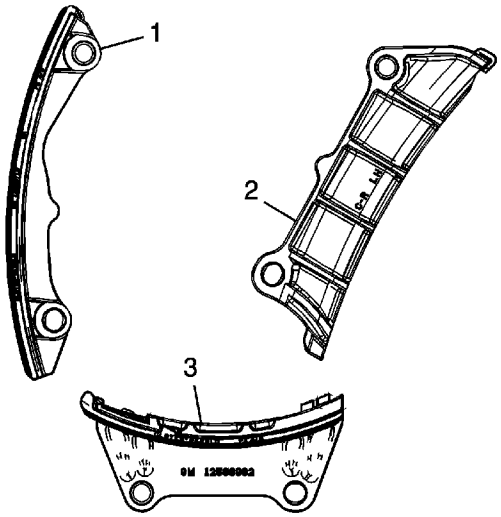


8. Align the left exhaust camshaft position actuator sprocket alignment circle mark (2) with the timing camshaft drive chain link (1).

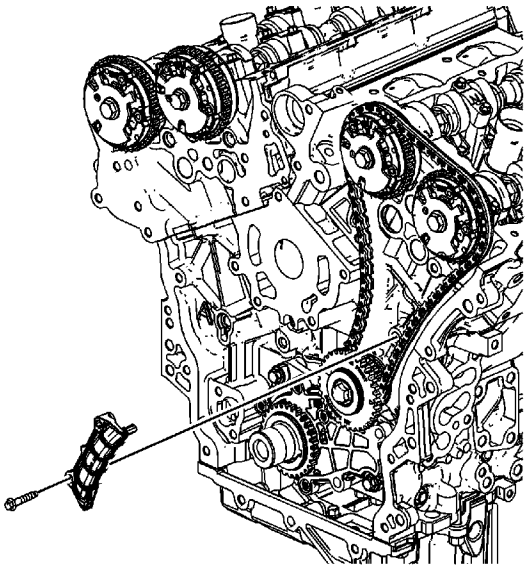


9. Align the left intake camshaft position actuator sprocket alignment circle mark (1) with the timing camshaft drive chain link (2).

Secondary Camshaft Drive Chain Guide Installation - Left Side



1. Ensure that the left secondary camshaft drive chain guide (2) is being installed.



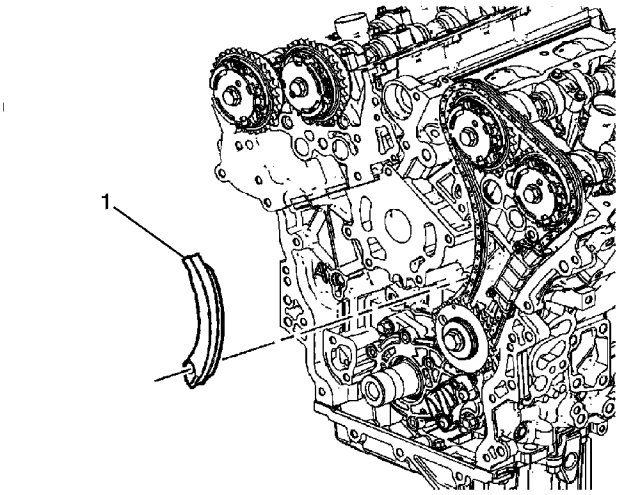
2. Position the left secondary camshaft drive chain guide.

   Caution: Refer to Fastener Caution in the Preface section.

3. Install the secondary camshaft drive chain guide bolts and tighten to **23 N·m (17 lb ft)**.

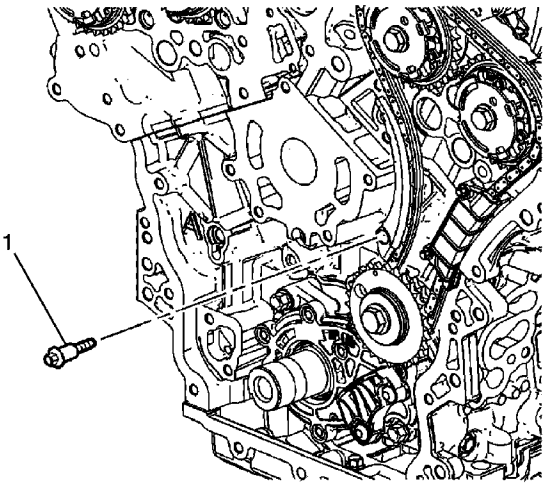
© 2010 General Motors Corporation. All rights reserved.

Secondary Camshaft Drive Chain Shoe Installation - Left Side



1. Install the left secondary camshaft drive chain shoe (1).

Caution: Refer to Fastener Caution in the Preface section.



© 2010 General Motors Corporation. All rights reserved.

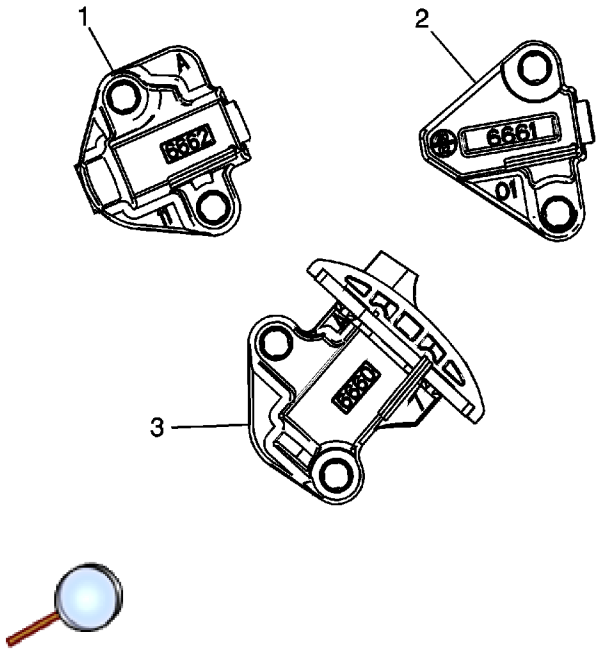
2. Install the secondary camshaft drive chain shoe to cylinder block retaining bolt (1) and tighten to **23 N·m (17 lb ft)**.

Secondary Camshaft Drive Chain Tensioner Installation - Left Side

Special Tools

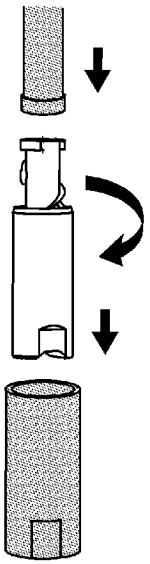
- *EN-46112* Tensioner Retraction Pins
- *J-45027* Tensioner Tool

For equivalent regional tools, refer to Special Tools.

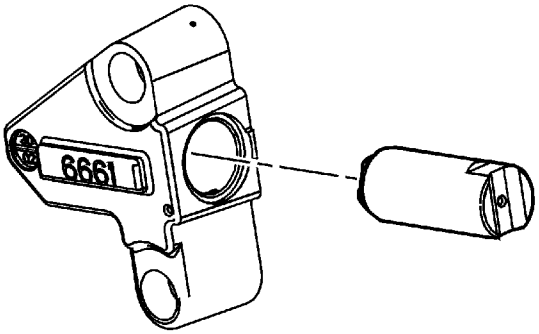


1. Ensure that the left secondary camshaft drive chain tensioner (2) is being installed.

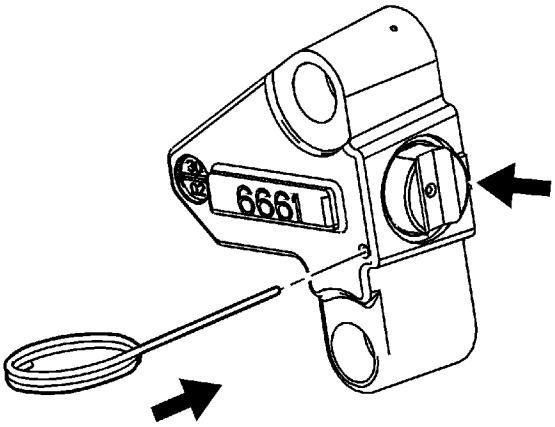
© 2010 General Motors Corporation. All rights reserved.



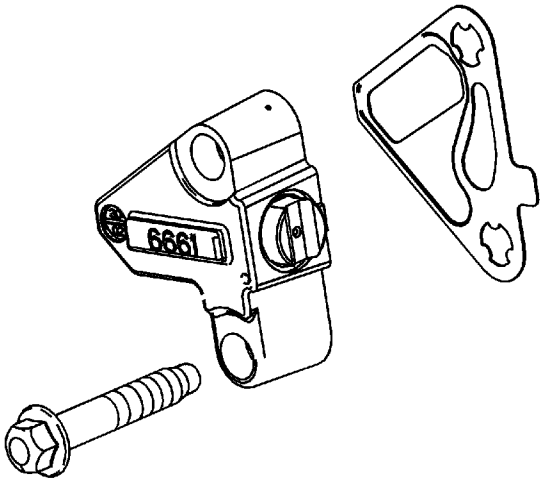
2. Using the *J-45027* tool , reset the left secondary camshaft drive chain tensioner plunger.



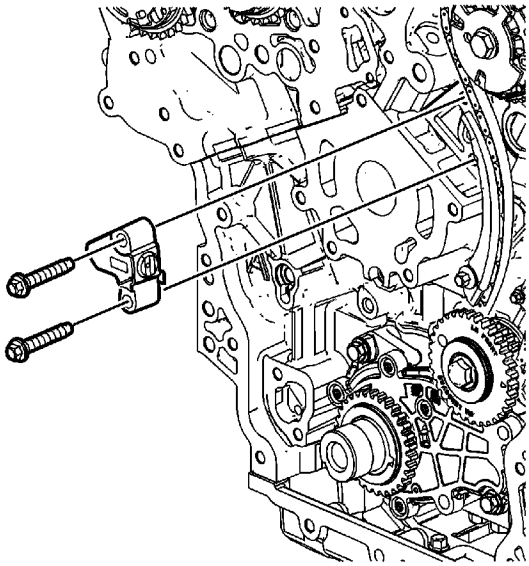
3. Install the plunger into the left secondary camshaft drive chain tensioner body.



4. Compress the plunger into the body and lock the left secondary camshaft drive chain tensioner by inserting the *EN-46112* pins into the access hole in the side of the left secondary camshaft drive chain tensioner body.
5. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed.

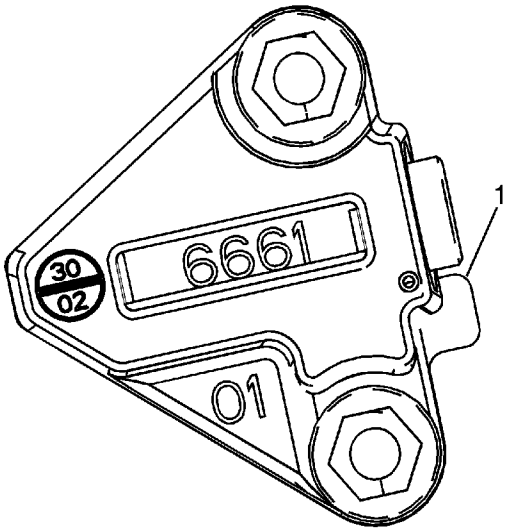


6. Install a NEW left secondary camshaft drive chain tensioner gasket to the left secondary camshaft drive chain tensioner.
7. Install the left secondary camshaft drive chain tensioner bolts through the left secondary camshaft drive chain tensioner and gasket.
8. Ensure the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.



9. Place the left secondary camshaft drive chain tensioner into position and loosely install the bolts to the block.

Caution: Refer to Fastener Caution in the Preface section.

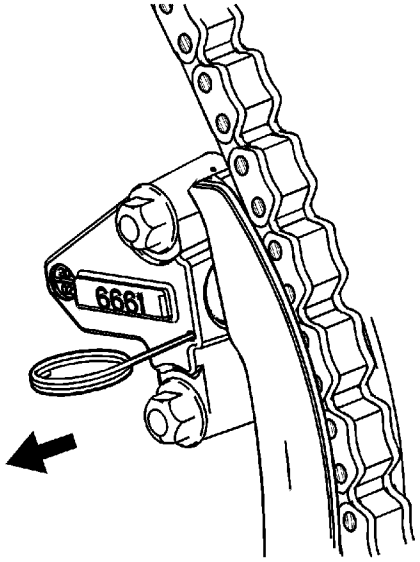


10. Verify the proper placement of the left secondary camshaft drive chain tensioner gasket tab (1).
    10.1. First Pass

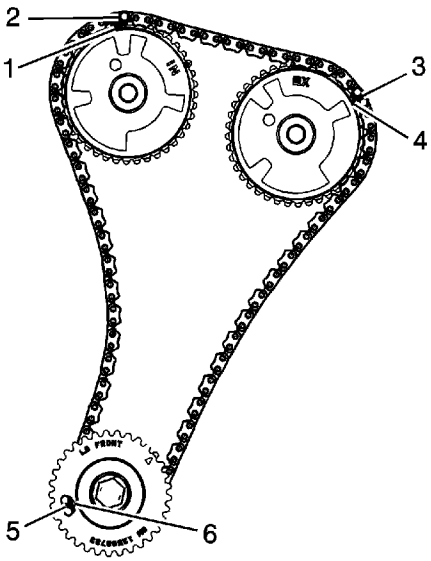
Tighten the left secondary camshaft drive chain tensioner bolts to **5 N·m (44 lb in)**.

10.2. Final Pass

Tighten the left secondary camshaft drive chain tensioner bolts to **23 N·m (17 lb ft)**.

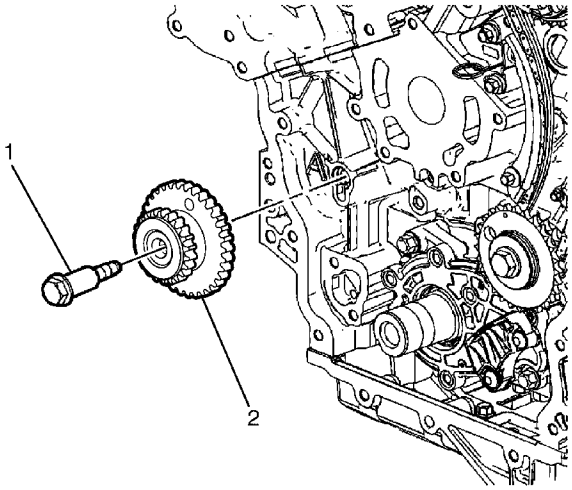


11. Release the left secondary camshaft drive chain tensioner by pulling out the *EN-46112* pins and unlocking the tensioner plunger.



12. Verify the left secondary camshaft drive chain timing mark alignments (1-6). Also refer to Camshaft Timing Drive Chain Alignment Diagram - Stage One.

Camshaft Intermediate Drive Chain Idler Installation - Right Side



Note: The recessed hub and the smaller sprocket of the right camshaft intermediate drive chain idler (2) is installed outward. The raised hub and the larger sprocket of the right camshaft intermediate drive chain idler (2) is installed towards the block.

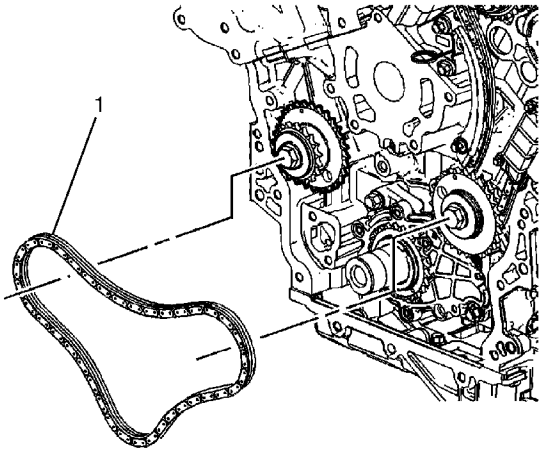
1. Install the right camshaft intermediate drive chain idler (2).

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the camshaft intermediate drive chain idler bolt (1) and tighten to **58 N·m (43 lb ft)**.

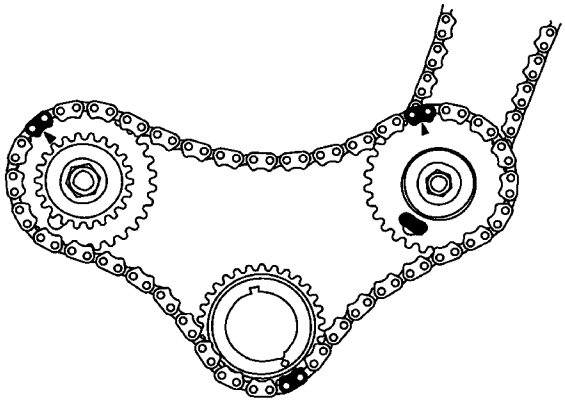
© 2010 General Motors Corporation. All rights reserved.

Primary Camshaft Intermediate Drive Chain Installation



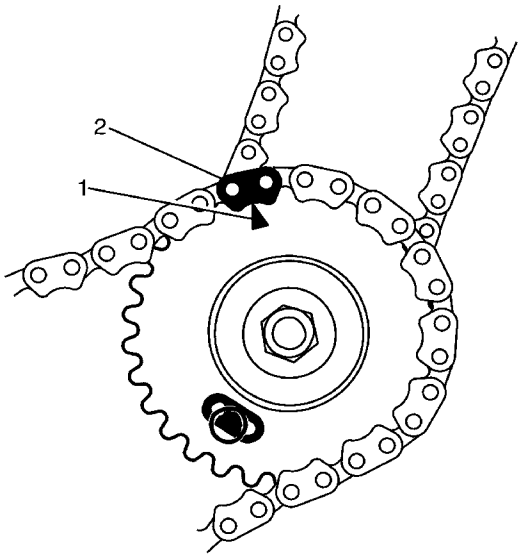
Important: Ensure that the crankshaft is in the stage one timing drive assembly position.

1. Install the primary camshaft drive chain (1).

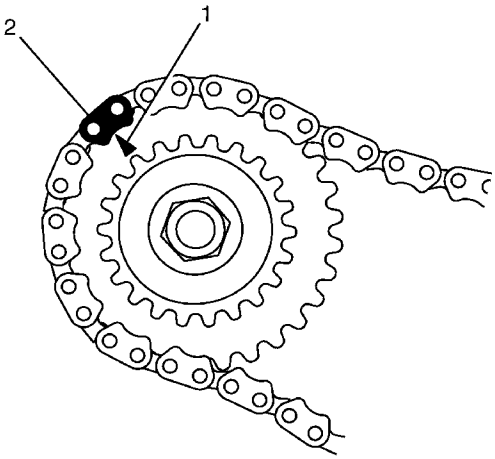


© 2010 General Motors Corporation. All rights reserved.

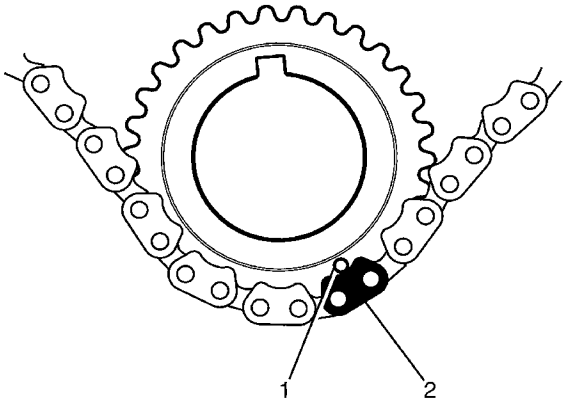
2. Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket.



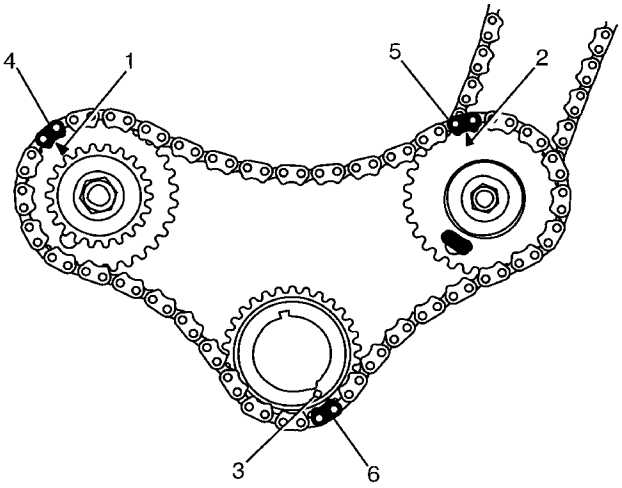
3. The left camshaft intermediate drive chain idler timing mark (1) will align with a timing camshaft drive chain link (2).



4. The right camshaft intermediate drive chain idler timing mark (2) will align with a timing camshaft drive chain link (1).

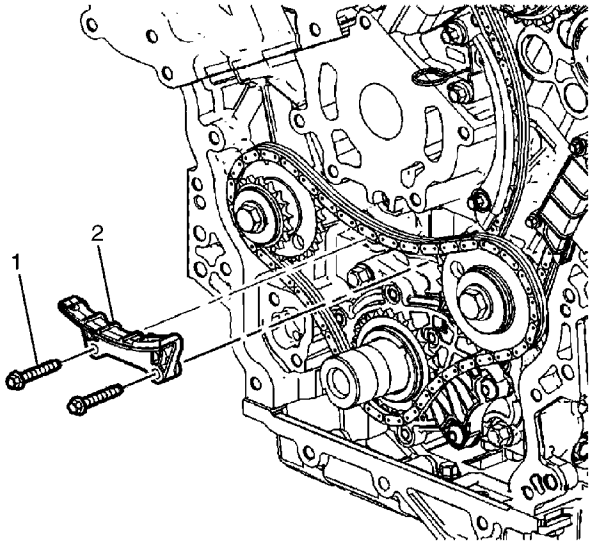


5. The crankshaft sprocket timing mark (2) will align with a timing camshaft drive chain link (1).



6. Ensure all the timing marks (2, 3, 6) are properly aligned with the timing camshaft drive chain links (1, 4, 5).

Primary Timing Chain Guide Installation - Upper



1. Install the primary camshaft drive chain upper guide (2).

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the primary camshaft drive chain upper guide to cylinder block retaining bolts (1) and tighten to **23 N·m (17 lb ft)**.

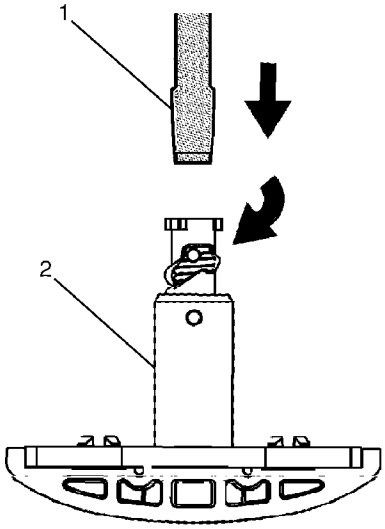
© 2010 General Motors Corporation. All rights reserved.

Primary Camshaft Intermediate Drive Chain Tensioner Installation

Special Tools

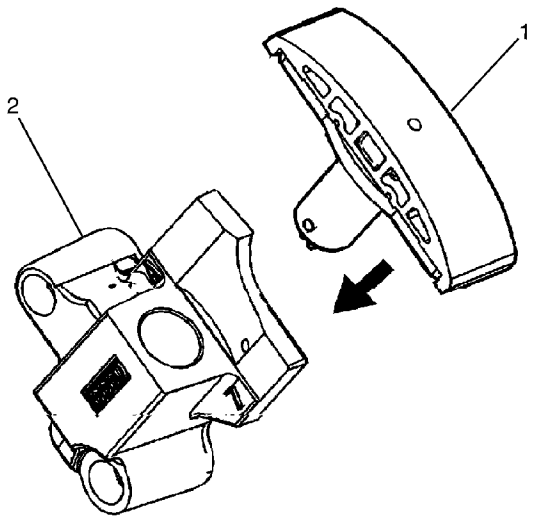
- *EN 46105* Camshaft Locking Tools
- *EN 46111* Crankshaft Rotation Socket
- *EN 46112* Tensioner Retraction Pins
- *J 45027* Tensioner Tool

For equivalent regional tools, refer to Special Tools.

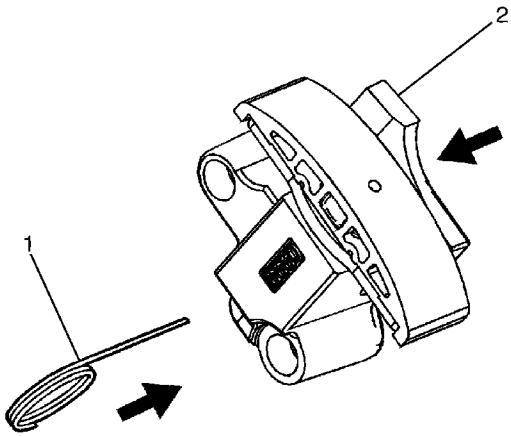


1. Using the *J 45027* tool (1) reset the primary camshaft drive chain tensioner plunger (2).

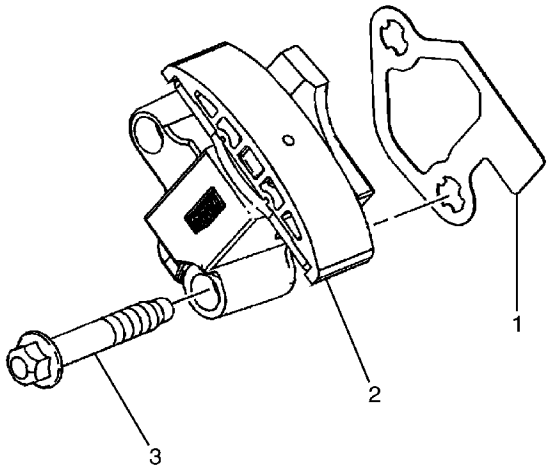
© 2010 General Motors Corporation. All rights reserved.



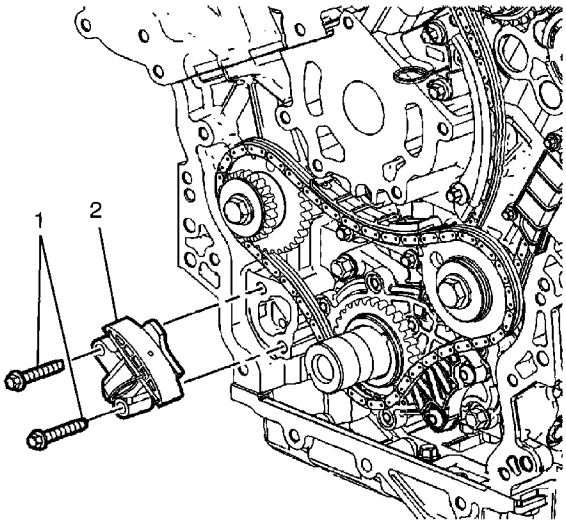
2. Install the plunger (1) into the primary camshaft drive chain tensioner body (2).



3. Compress the plunger into the body and lock the primary camshaft drive chain tensioner (2) by inserting the *EN 46112* pins (1) into the access hole in the side of the primary camshaft drive chain tensioner (2).
4. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed.

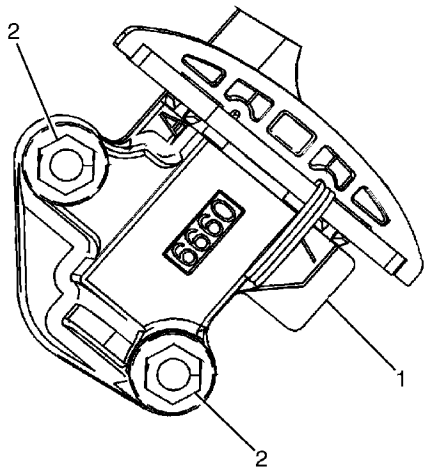


5. Install a NEW primary camshaft drive chain tensioner gasket (1) to the primary camshaft drive chain tensioner (2).
6. Install the primary camshaft drive chain tensioner bolts (3) through the primary camshaft drive chain tensioner (2) and gasket (1).
7. Ensure the primary camshaft drive chain tensioner mounting surface on the engine block does not have any burrs or defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket (1).



8. Place the primary camshaft drive chain tensioner (2) into position and loosely install the primary camshaft drive chain tensioner to cylinder block retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.

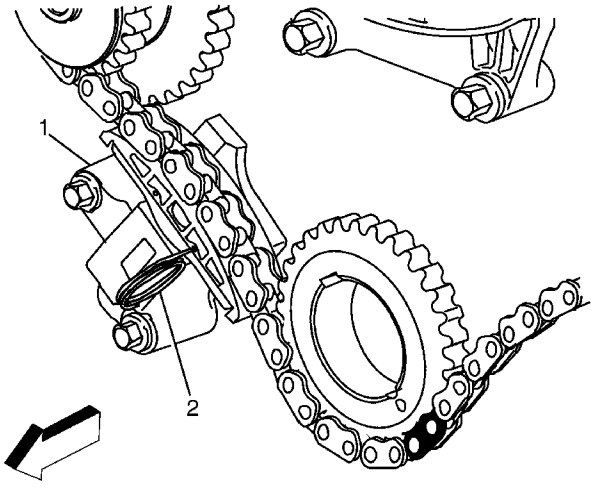


9. Verify the proper placement of the primary camshaft drive chain tensioner gasket tab (1).
10. Tighten the primary camshaft drive chain tensioner to cylinder block retaining bolts (2)
    10.1. First Pass

    Tighten the bolts to **5 N·m (44 lb in)**.

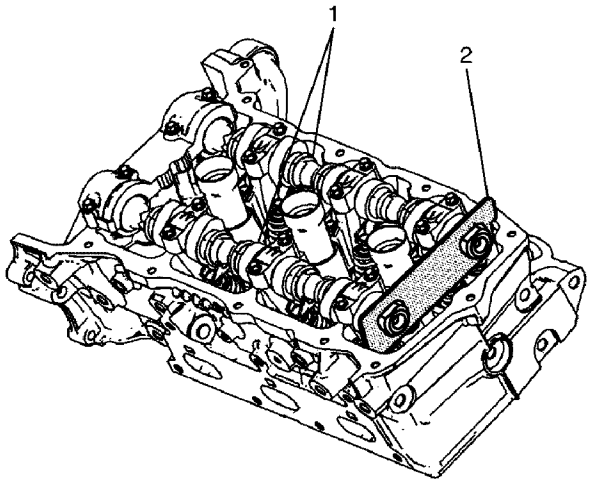
    10.2. Final Pass

    Tighten the bolts to **23 N·m (17 lb ft)**.

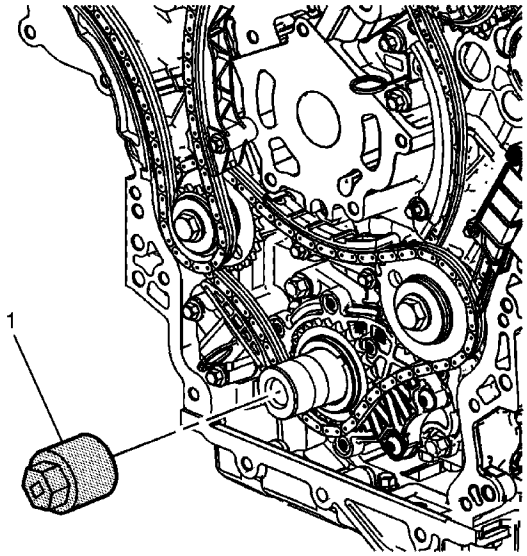


11. Release the primary camshaft drive chain tensioner (1) by pulling out the *EN 46112* pins (2).

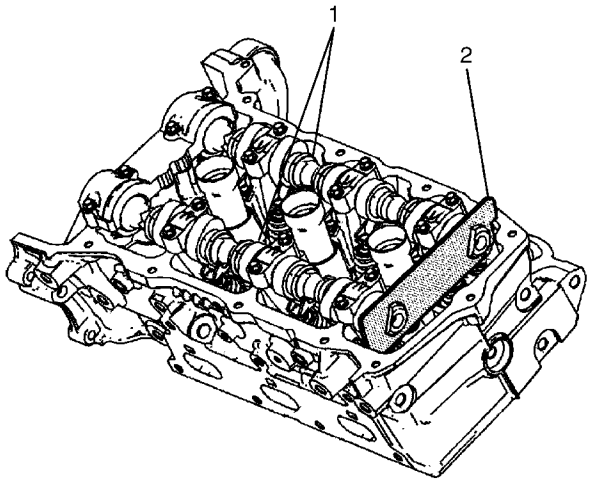
12. Verify the primary and left secondary camshaft drive chain timing mark alignments (1-12). Refer to Camshaft Timing Drive Chain Alignment Diagram.



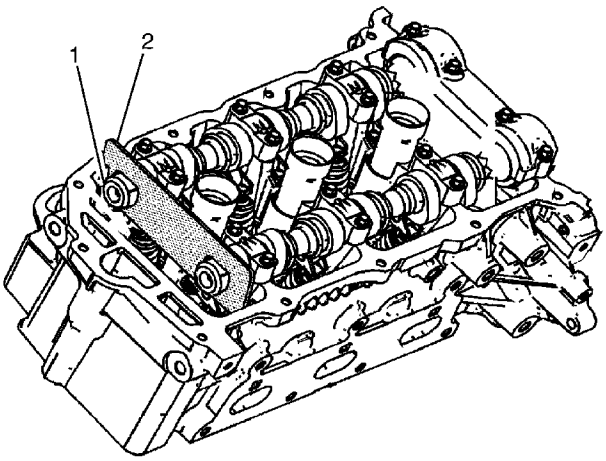
13. Remove the *EN 46105* tools (2) from the rear of the left hand camshafts (1).



14. Using the *EN 46111* socket (1) rotate the crankshaft and crankshaft sprocket from the stage one alignment position (1) to the stage two alignment position, 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components.

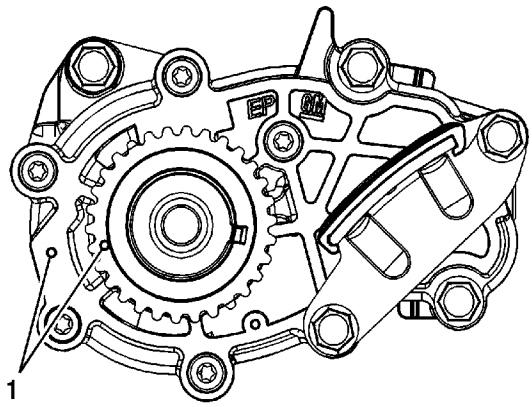


15. Install the *EN 46105* tools (2) onto the rear of the left hand camshafts (1).

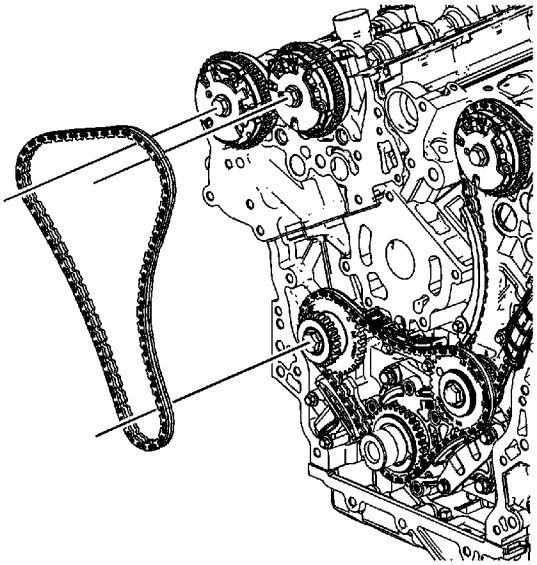


16. Install the *EN 46105* tools (2) onto the rear of the right hand camshafts (1).

Secondary Camshaft Drive Chain Installation - Right Side

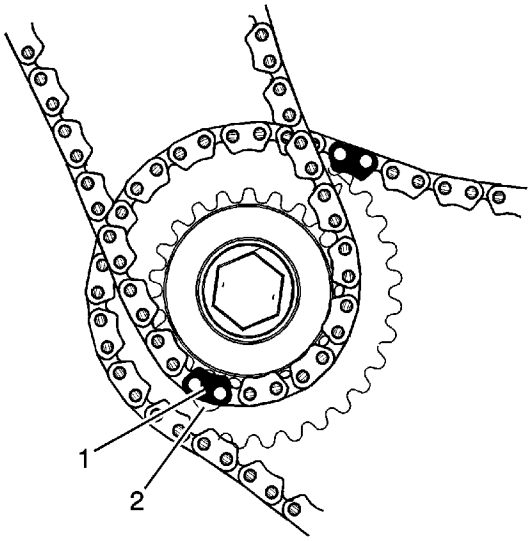


1. Ensure that the crankshaft is in the stage 2 timing drive assembly position (1).

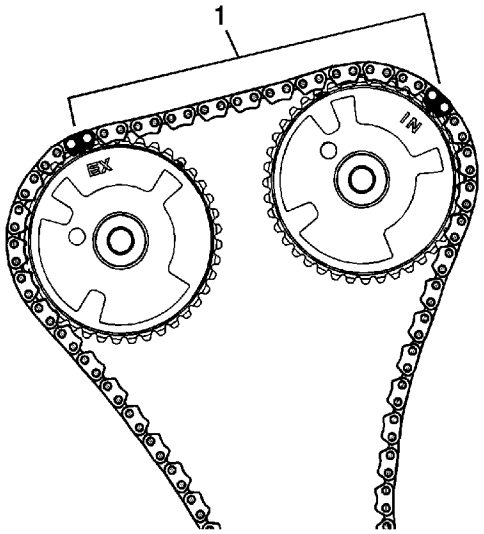


2. Install the right secondary camshaft drive chain.

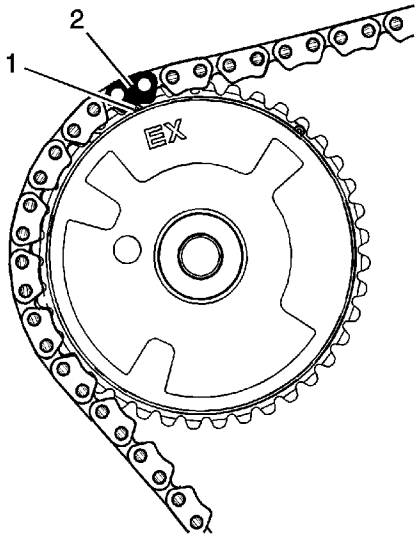
© 2010 General Motors Corporation. All rights reserved.



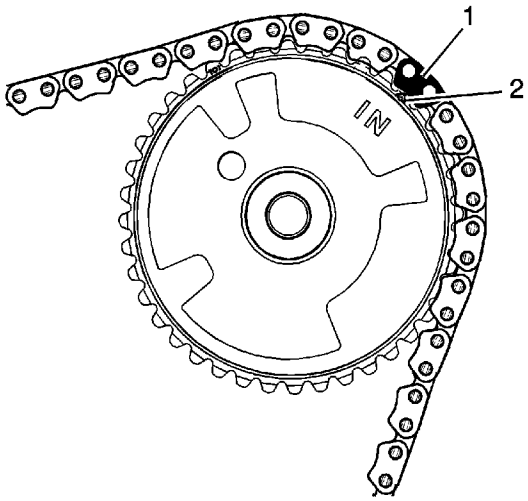
3. Place the secondary camshaft drive chain around the right camshaft intermediate drive chain idler outer sprocket, aligning the timing camshaft drive chain link (1) with the alignment access hole (2) made in the right camshaft intermediate drive chain idler inner sprocket.



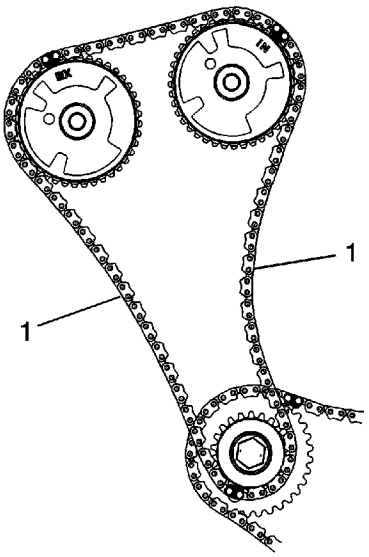
4. Wrap the secondary camshaft drive chain around both right actuator drive sprockets.
5. Ensure there are 10 links (1) between the timing camshaft drive chain links for the camshaft position actuator sprockets.



6. Align the right exhaust camshaft position actuator sprocket alignment triangle mark (1) with the timing camshaft drive chain link (2).

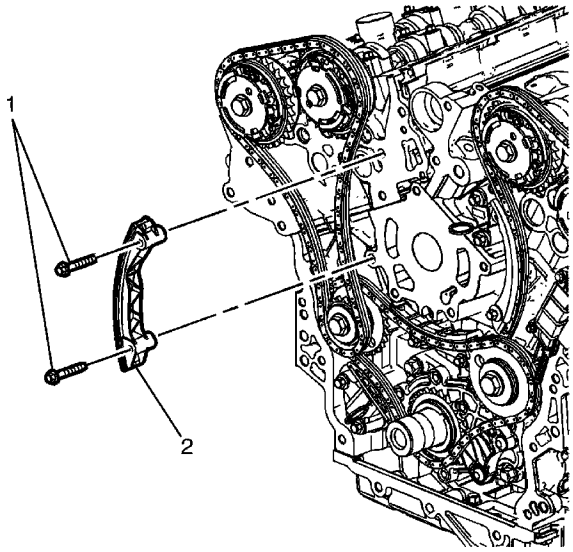


7. Align the right intake camshaft position actuator sprocket alignment triangle mark (2) with the timing camshaft drive chain link (1).



8. There will be 22 links (1) between the right camshaft intermediate drive chain idler timing camshaft drive chain link and each right camshaft position actuator sprocket timing camshaft drive chain link.

Secondary Camshaft Drive Chain Guide Installation - Right Side



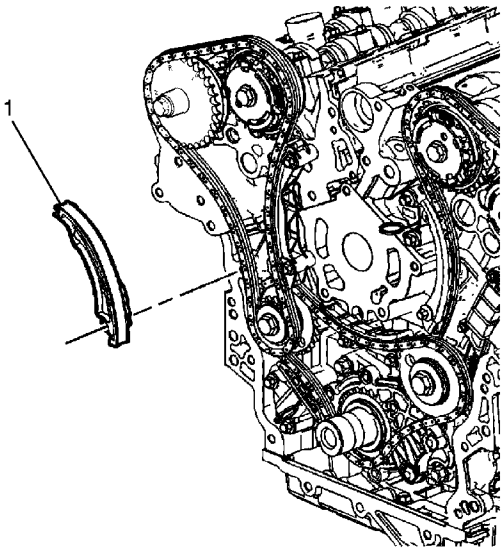
1. Position the right secondary camshaft drive chain guide (2).

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the secondary camshaft drive chain guide to cylinder block retaining bolts (1) and tighten to **23 N·m (17 lb ft)**.

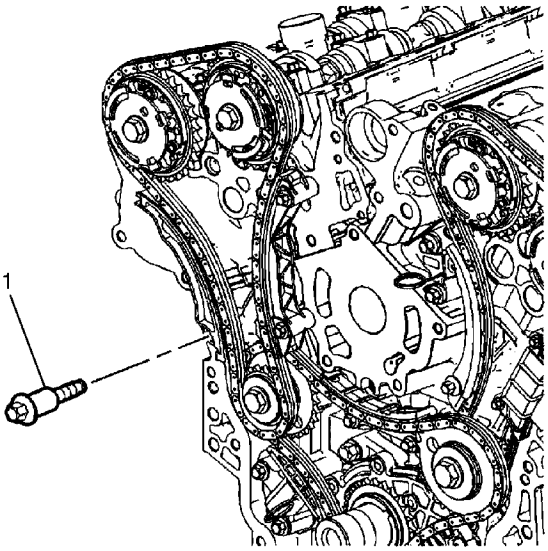
© 2010 General Motors Corporation. All rights reserved.

Secondary Camshaft Drive Chain Shoe Installation - Right Side



1. Position the right secondary camshaft drive chain shoe (1).

   Caution: Refer to Fastener Caution in the Preface section.



2. Install the right secondary camshaft drive chain shoe to cylinder block retaining bolt (1) and

© 2010 General Motors Corporation. All rights reserved.

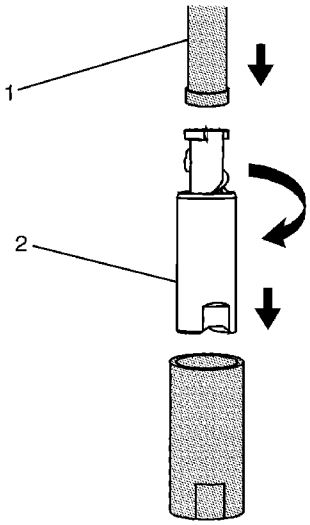
tighten to **23 N·m (17 lb ft)**.

Secondary Camshaft Drive Chain Tensioner Installation - Right Side

Special Tools

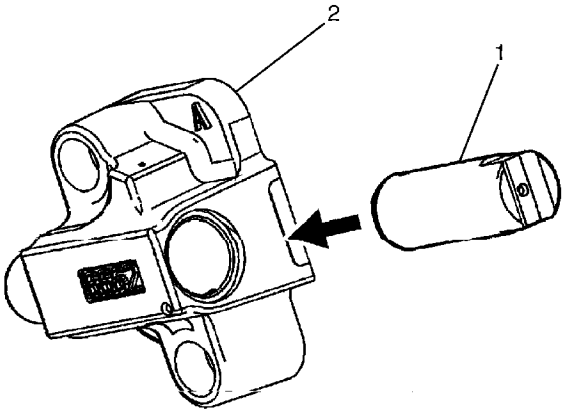
- *EN 46112* Tensioner Retraction Pins
- *J 45027* Tensioner Tool

For equivalent regional tools, refer to Special Tools.

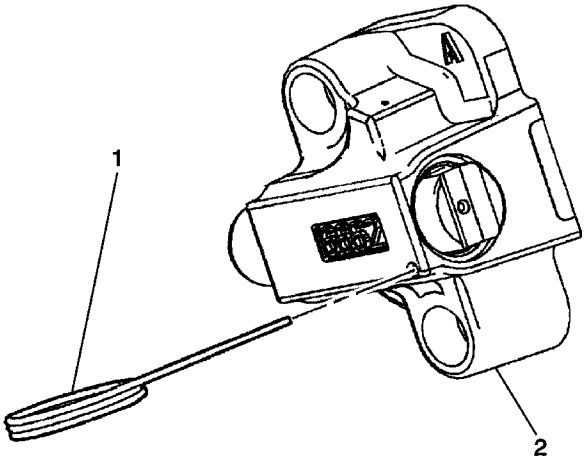


1. Using the *J 45027* tool reset the right secondary camshaft drive chain tensioner plunger.

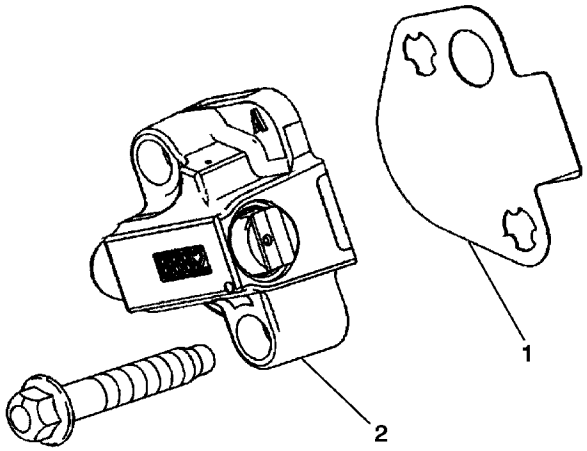
© 2010 General Motors Corporation. All rights reserved.



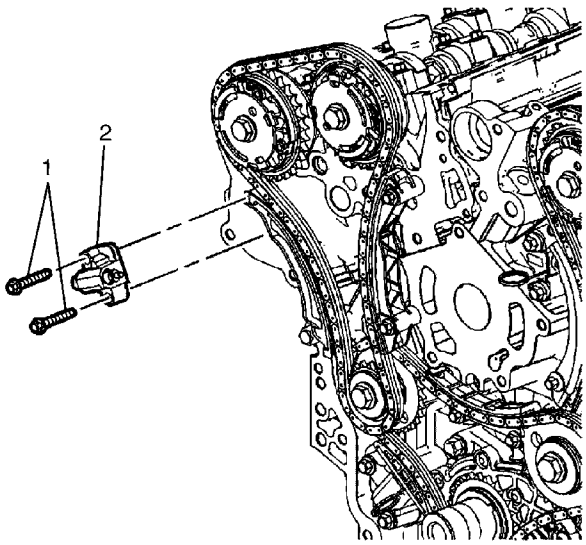
2. Install the plunger (1) into the right secondary camshaft drive chain tensioner body (2).



3. Compress the plunger into the body and lock the right secondary camshaft drive chain tensioner (2) by inserting the *EN 46112* pins (1) into the access hole in the side of the right secondary camshaft drive chain tensioner (2).
4. Slowly release pressure on the right secondary camshaft drive chain tensioner (2). The right secondary camshaft drive chain tensioner (2) should remain compressed.

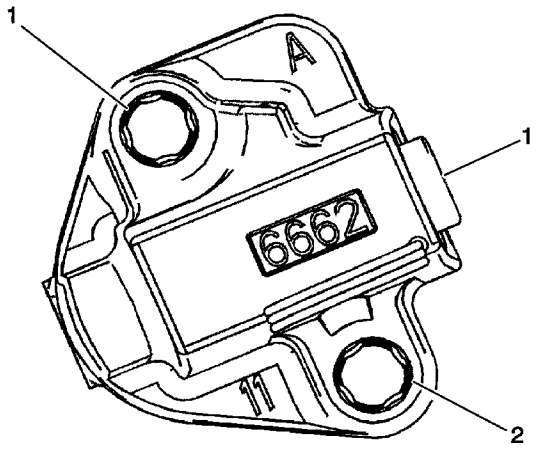


5. Install a NEW right secondary camshaft drive chain tensioner gasket (1) to the right secondary camshaft drive chain tensioner (2).
6. Install the right secondary camshaft drive chain tensioner bolts through the right secondary camshaft drive chain tensioner (2) and gasket (1).
7. Ensure the right secondary camshaft drive chain tensioner (2) mounting surface on the right cylinder head does not have any burrs or defects that may degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket (1).



8. Place the right secondary camshaft drive chain tensioner (2) into position and loosely install right secondary camshaft drive chain tensioner to cylinder block retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.

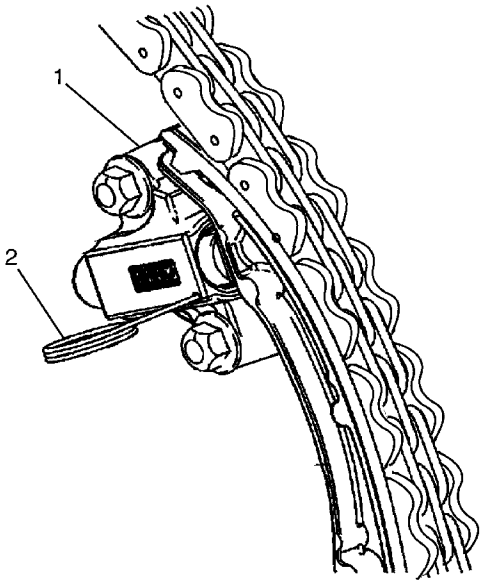


9. Verify the proper placement of the right secondary camshaft drive chain tensioner gasket tab (1).
10. Tighten the right secondary camshaft drive chain tensioner to cylinder block retaining bolts (2).
    10.1. First Pass

    Tighten the bolts to **5 N·m (44 lb in)**.

    10.2. Final Pass

    Tighten the bolts to **23 N·m (17 lb ft)**.



11. Release the right camshaft drive chain tensioner by pulling out the *EN 46112* pins and unlocking the tensioner plunger.

    Caution: Ensure that all timing chain tensioners are completely released. A timing chain tensioner that is not properly released can lead to serious engine damage.

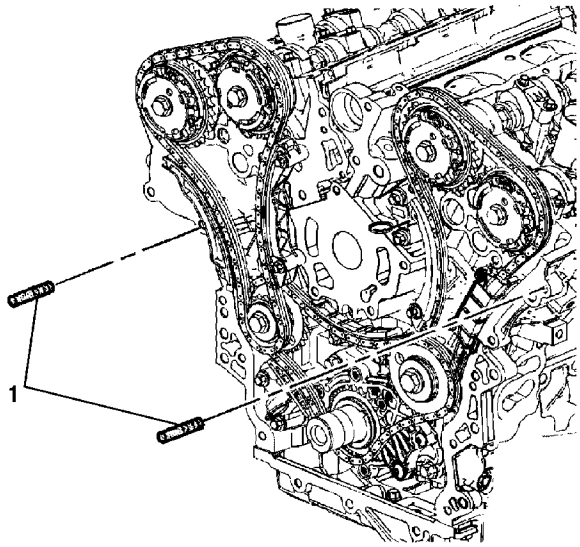
12. Verify all primary and secondary camshaft drive chain timing mark alignments. Refer to Camshaft Timing Drive Chain Alignment Diagram.

Engine Front Cover Installation

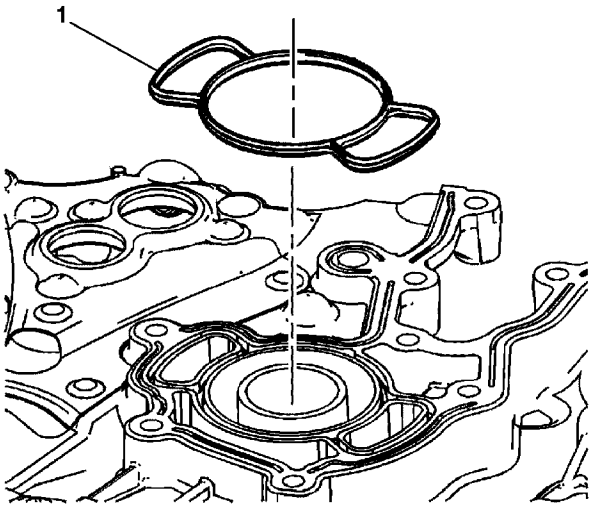
Special Tools

- *EN 46109* Guide Pin Set
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.

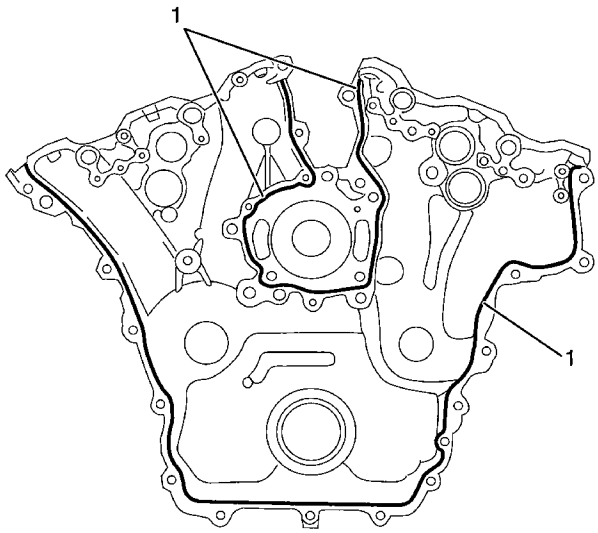


1. Install the 8 mm (0.315 in) guide from the *EN 46109* set (1) into the cylinder block positions as shown.

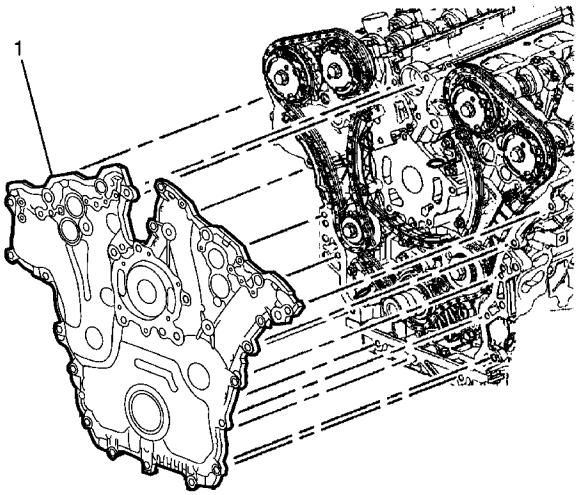


© 2010 General Motors Corporation. All rights reserved.

2. Install the NEW engine front cover to cylinder block seal (1).

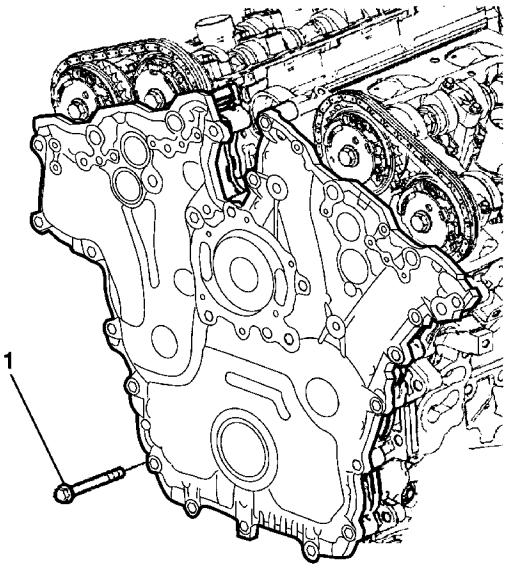


3. Place a 3 mm (0.118 in) bead of RTV sealant (1), on the engine front cover as shown.

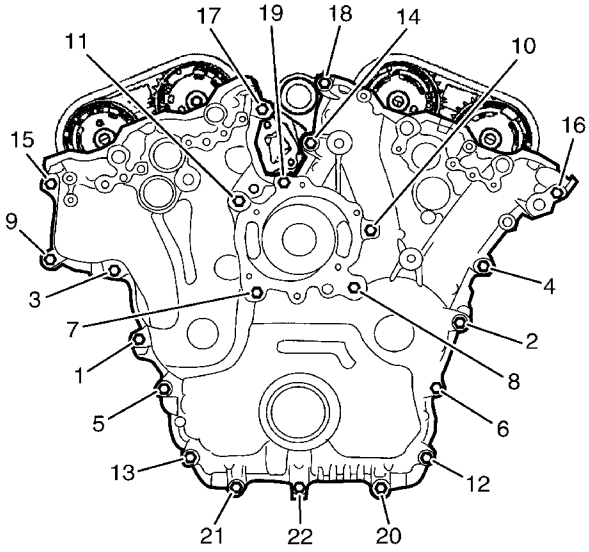


4. Place the engine front cover (1) onto the *EN 46109* set and slide into position.
5. Remove the *EN 46109* set from the cylinder block.

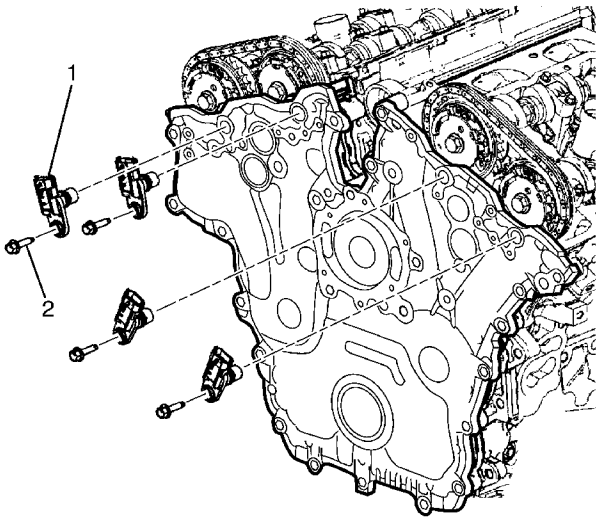
Caution: Refer to Fastener Caution in the Preface section.



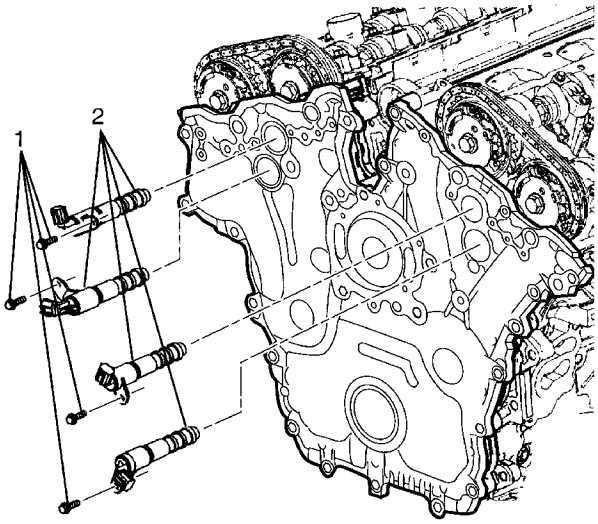
6. Hand start all the engine front cover to cylinder block retaining bolts (1).



7. Tighten the engine front cover to cylinder block retaining bolts in the sequence shown.
   7.1. Tighten the bolts a first pass in sequence to **20 N·m (17 lb ft)**.
   7.2. Tighten the bolts a second pass in sequence an additional 60 degrees using the *J 45059* meter .
8. Install NEW O-rings on the camshaft position sensors.



9. Install the camshaft position sensors (2).
10. Install the camshaft position sensor to front cover retaining bolts (1) and tighten to **10 N·m (89 lb in)**.



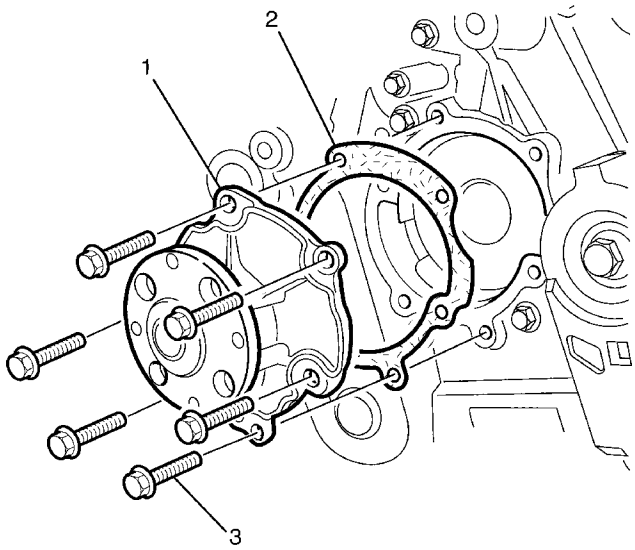
Note: LE0 and LW2 engines only have intake camshaft position actuator solenoids.

11. Install the camshaft position actuator solenoids (2).
12. Install the camshaft position actuator solenoid to front cover retaining bolts (1).
    12.1. Tighten the bolts to **10 N·m (89 lb in)**.
    12.2. Tighten the bolts a second pass in sequence an additional 60 degrees using the *J 45059* meter .

Water Pump Installation

Note: Make sure all mating surfaces are clean and free of grease.

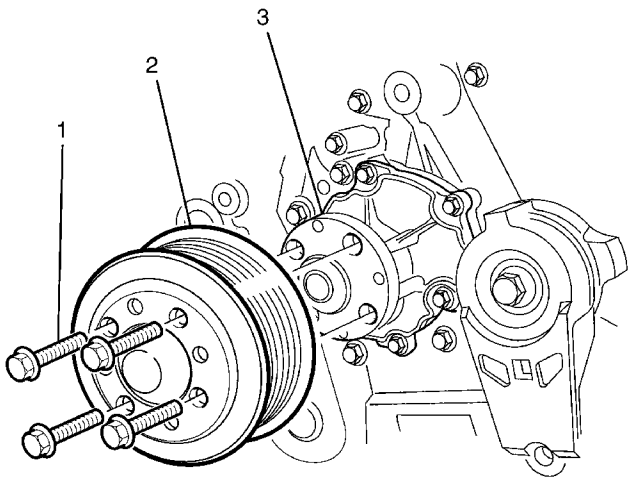
1. Using a water sealant install the water pump and gasket to front engine cover.
2. Make sure all retaining bolts are clean and free of debris.



3. Install the water pump (1) and NEW gasket (2).

Caution: Refer to Fastener Caution in the Preface section.

4. Install the water pump to engine front cover retaining bolts (3) and tighten to **10 N·m (89 lb in)**.



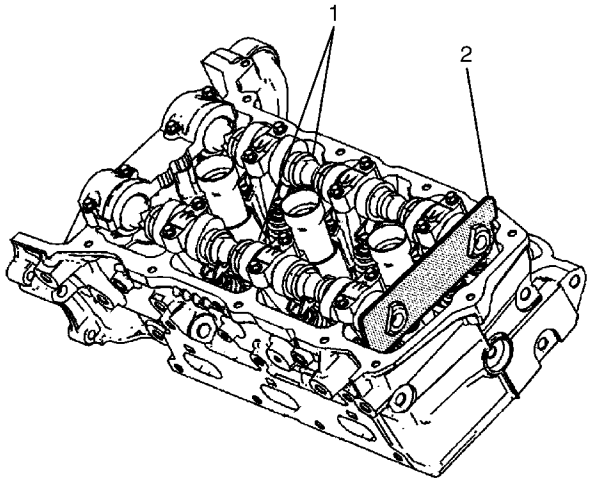
© 2010 General Motors Corporation. All rights reserved.

5. Install the water pump pulley (2) to the water pump (3)
6. Install the water pump pulley to water pump retaining bolts (1) and tighten to **10 N·m (89 lb in)**.

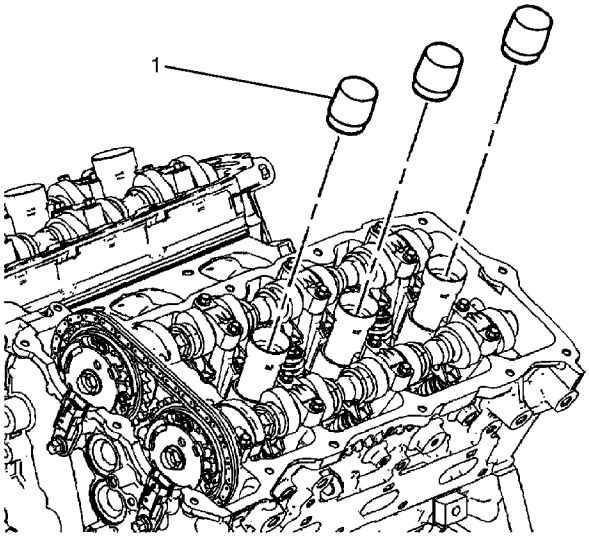
Camshaft Cover Installation - Left Side

Special Tools

- *EN 46101* Spark Plug Tube Seal Guide
- *EN 46105* Camshaft Locking Tools For equivalent regional tools, refer to Special Tools.

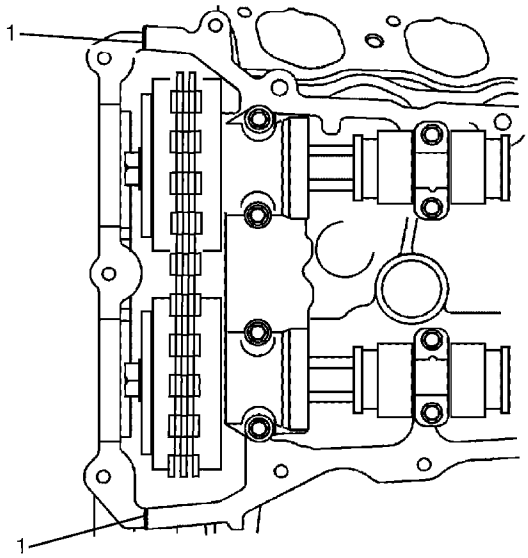


1. Remove the *EN 46105* tools (2) from the rear of the left hand camshafts (1).



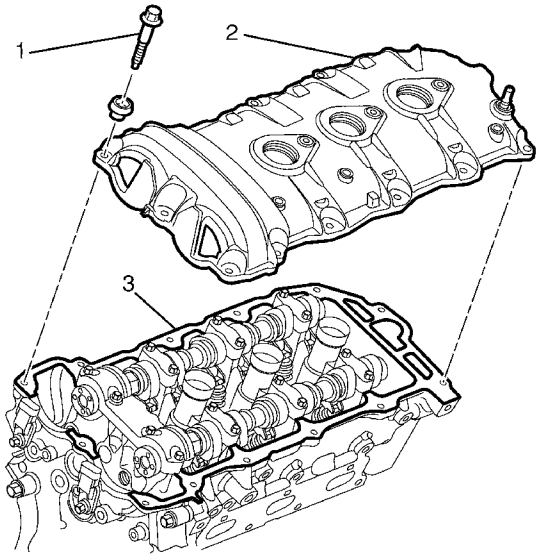
© 2010 General Motors Corporation. All rights reserved.

2. Install the *EN 46101* guide (1) onto the spark plug tubes of the left cylinder head.
3. Install the camshaft cover bolt grommets prior to installing the camshaft cover bolts.
4. Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.



Note: Make sure the sealing surfaces of the cylinder head and camshaft cover are clean.

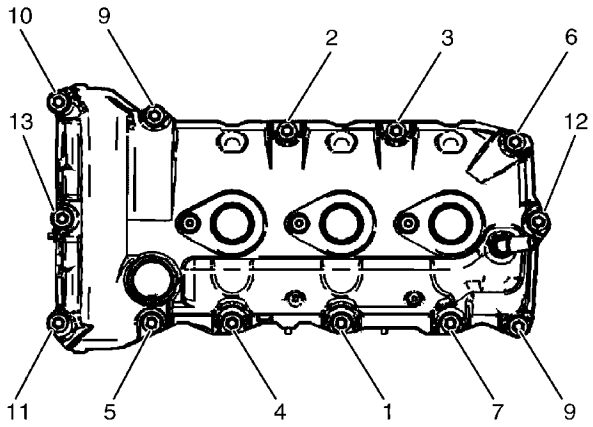
5. Place a 3 mm bead of RTV sealant (1) on the join line between the engine front cover and the cylinder head.
6. Install a NEW camshaft cover seal and NEW grommets.



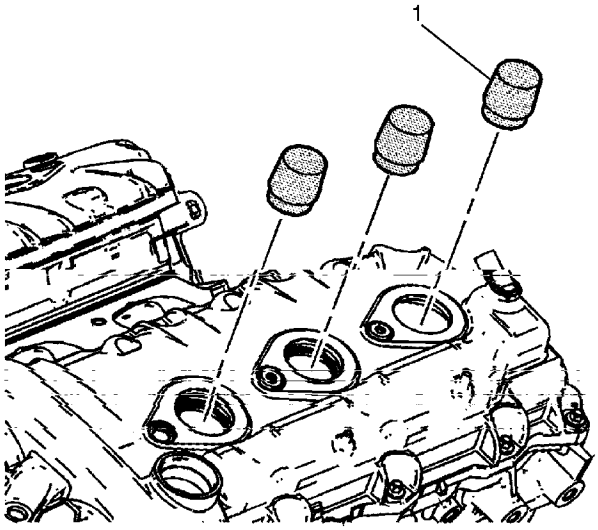
7. Install the camshaft cover (2) from the cylinder head (3).

8. Loosely install the left camshaft cover to cylinder head retaining bolts (1).

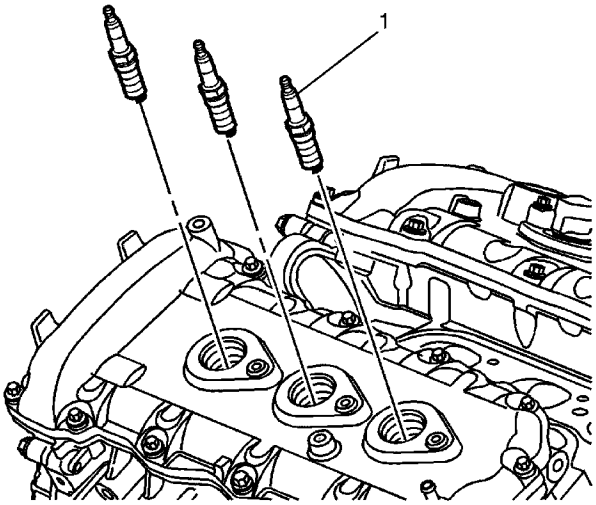
   Caution: Refer to Fastener Caution in the Preface section.



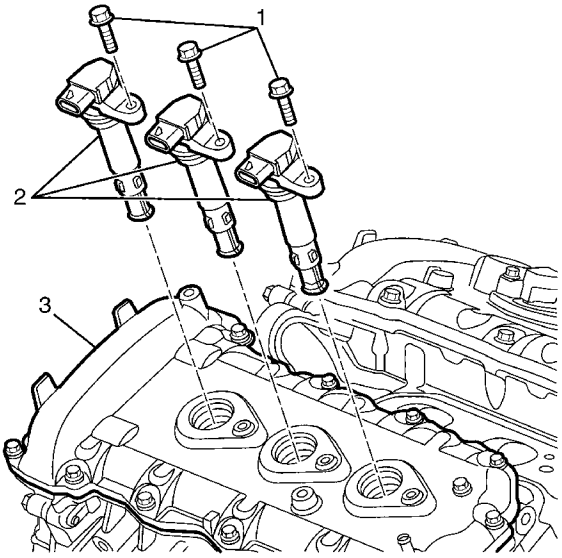
9. Tighten the left camshaft cover to cylinder head retaining bolts in the sequence shown and tighten in sequence to **10 N·m (89 lb in)**.



10. Remove the *EN 46101* guide (1) from the spark plug tubes of the left cylinder head.



11. Install the spark plugs (1).



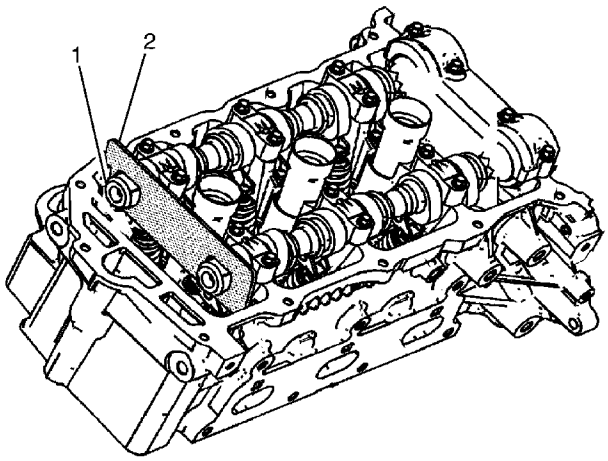
Note: DO NOT damage the spark plug and/or the seal in the left camshaft cover or an engine misfire condition may result.

12. Install the ignition coils (2) to the camshaft cover (3).
13. Install each ignition coil to camshaft cover retaining bolt (1) and tighten to **10 N·m (89 lb in)**.

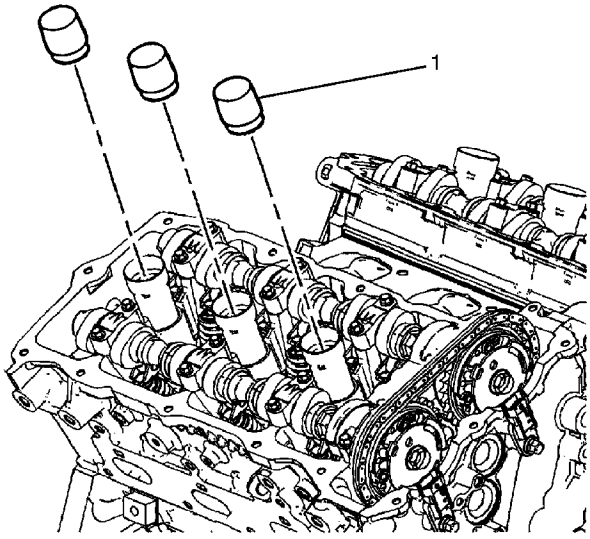
Camshaft Cover Installation - Right Side

Special Tools

- *EN 46101* Spark Plug Tube Seal Guide
- *EN 46105* Camshaft Locking Tools For equivalent regional tools, refer to Special Tools.

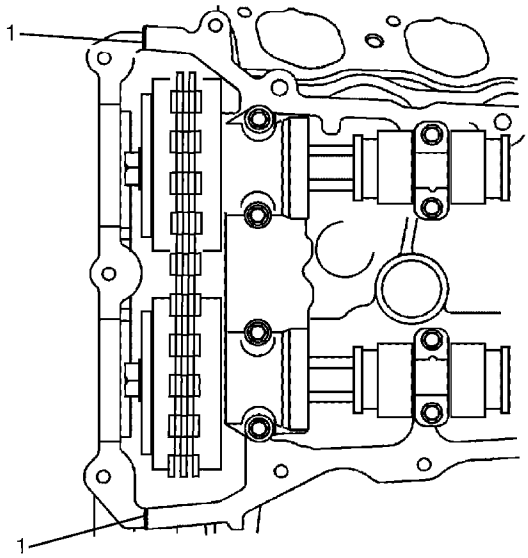


1. Remove the *EN 46105* tools (2) from the rear of the right camshafts (1).

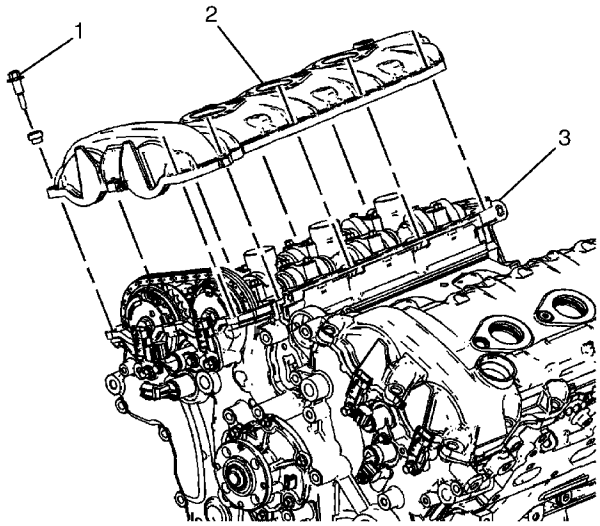


© 2010 General Motors Corporation. All rights reserved.

2. Install the *EN 46101* guide (1) onto the spark plug tubes of the right cylinder head.
3. Install the camshaft cover bolt grommets prior to installing the camshaft cover bolts.
4. Wipe the camshaft cover sealing surface on the right cylinder head with a clean, lint-free cloth.

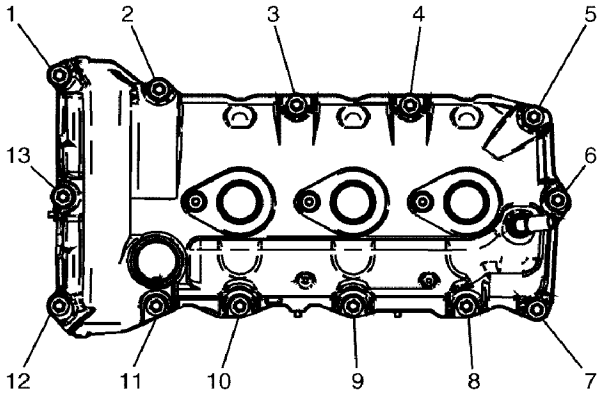


5. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines (1).

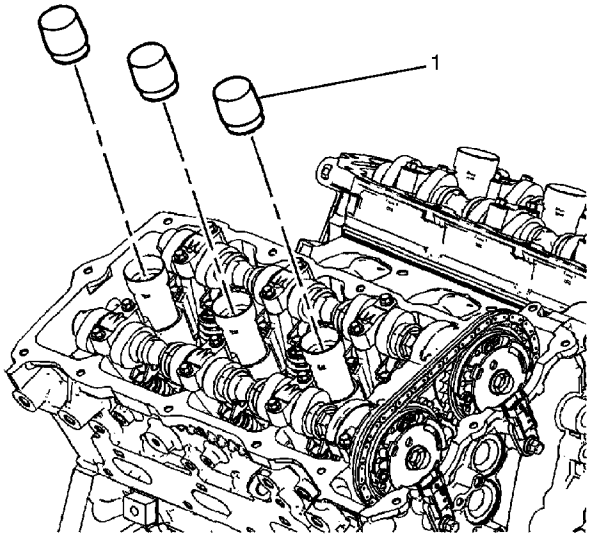


6. Place the right camshaft cover (2) into position onto the right cylinder head (3).
7. Loosely install the right camshaft cover bolts (1).

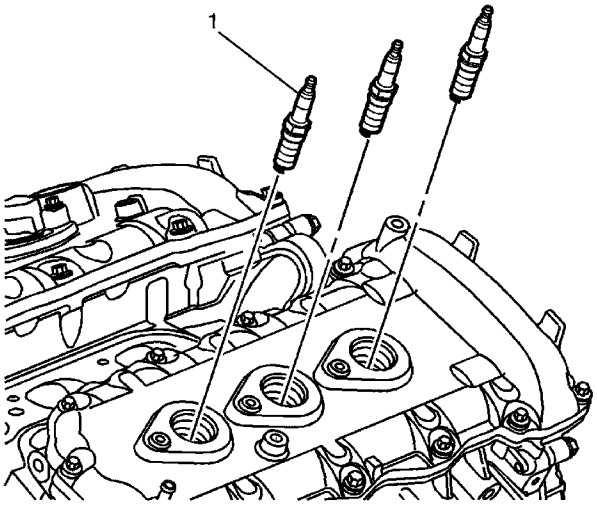
Caution: Refer to Fastener Caution in the Preface section.



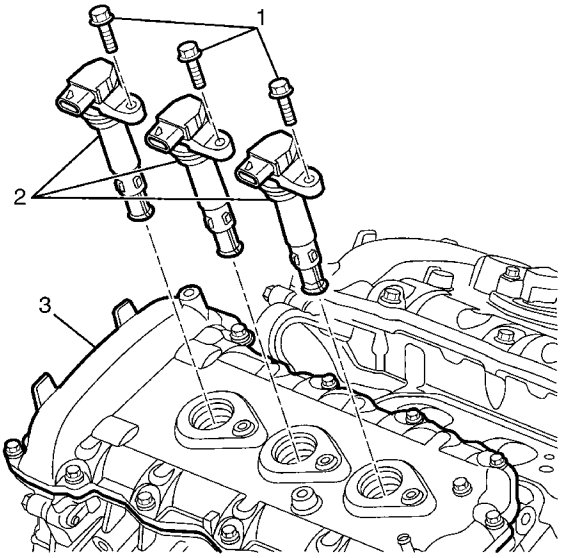
8. Tighten the left camshaft cover to cylinder head retaining bolts in the sequence shown and tighten in sequence to **10 N·m (89 lb in)**.



9. Remove the *EN 46101* guide (1) from the spark plug tubes of the right cylinder head.



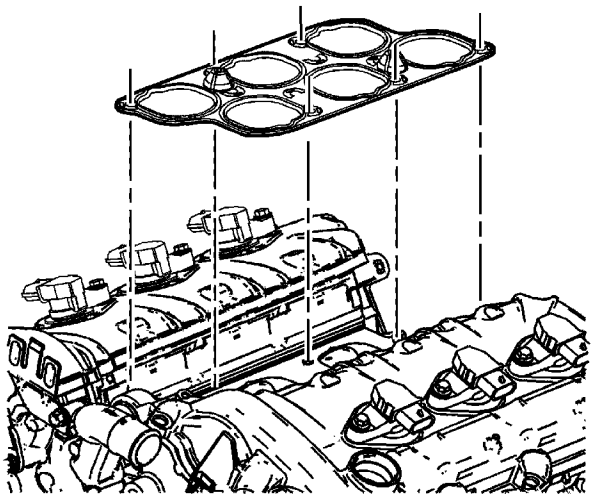
10. Install the NEW spark plugs (1) and tighten to **20 N·m (15 lb ft)**.



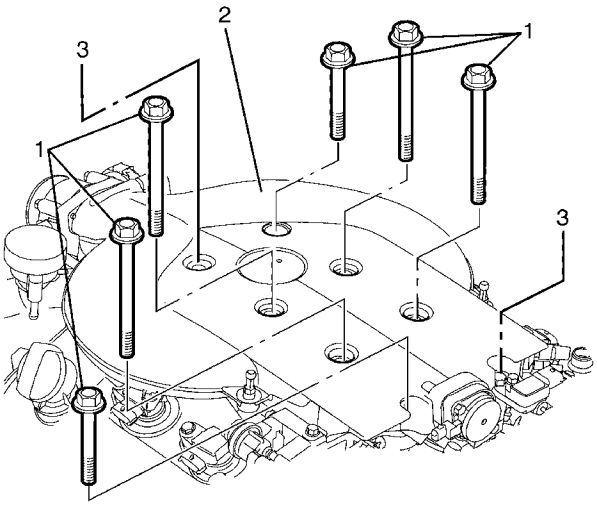
Note: DO NOT damage the spark plug and/or the seal in the left camshaft cover or an engine misfire condition may result.

11. Install the ignition coils (2).
12. Install each ignition coil to camshaft cover retaining bolt (1) and tighten to **10 N·m (89 lb in)**.

Intake Manifold Installation



1. Install the NEW intake manifold gasket.



2. Install the intake manifold (2) and the throttle body (3) as an assembly as an assembly.

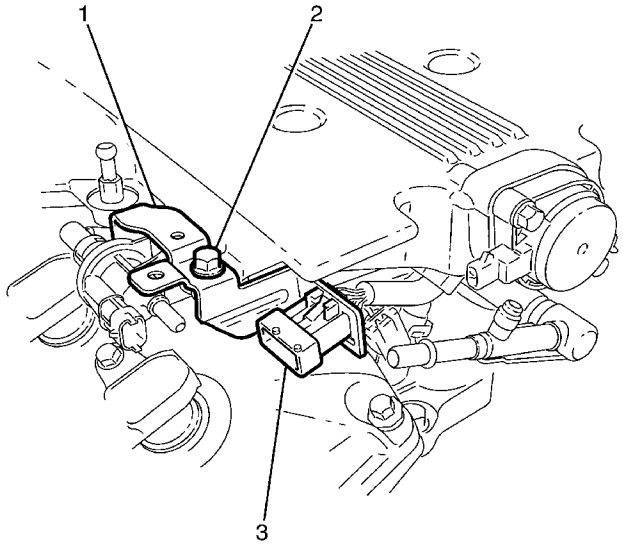
Caution: Refer to Fastener Caution in the Preface section.

Note: Tighten the intake manifold bolts (1) in a circular pattern starting at the center (long

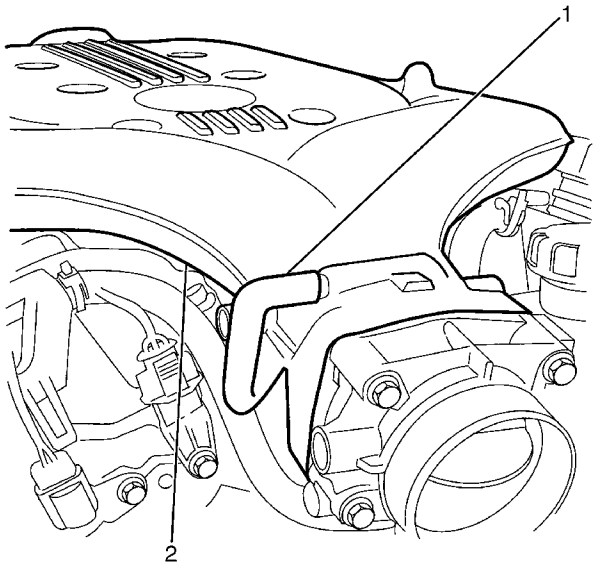
© 2010 General Motors Corporation. All rights reserved.

bolts) and moving outward.

3. Install the intake manifold bolts (1) and tighten to **23 N·m (17 lb ft)**.



4. Install the fuel injector harness electrical connector/EVAP valve mounting bracket (1).
5. Install the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2) and tighten to **10 N·m (89 lb in)**.
6. Attach the fuel injector harness electrical connector (3) to the fuel injector harness electrical connector/EVAP valve mounting bracket (1).



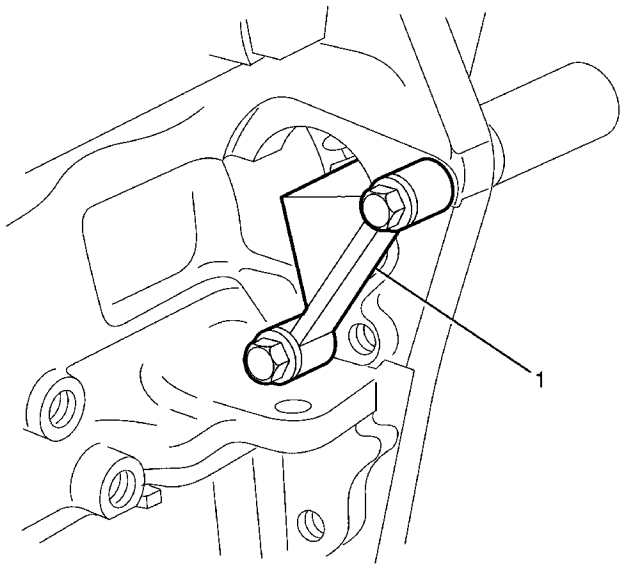
7. Connect the EVAP hose (1) to the upper intake manifold (2).
8. Install the PCV tube and PCV fresh air tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.

Engine Flywheel Installation

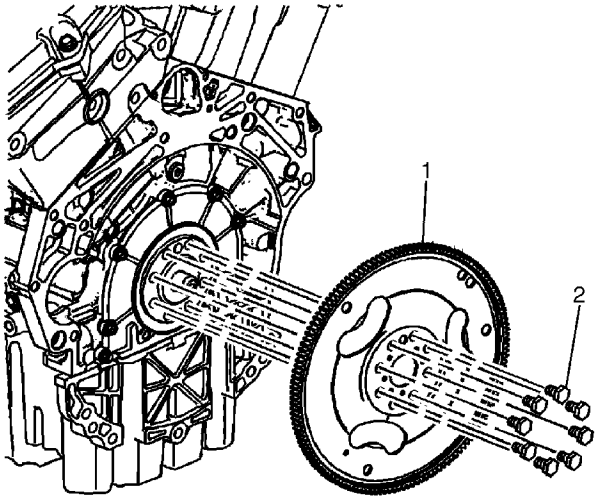
Special Tools

- *EN 46106* Engine Flywheel Holding Tool
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.



1. Install the *EN 46106* tool (1).



© 2010 General Motors Corporation. All rights reserved.

2. Place the automatic transmission flex plate (2) in position.
3. Install 2 NEW automatic transmission flex plate to crankshaft retaining bolts (1) in location at the top and bottom of the automatic transmission flex plate (2) bolt pattern allowing the automatic transmission flex plate (2) to hang in position.

   Caution: Refer to Fastener Caution in the Preface section.

4. Install the remaining NEW automatic transmission flex plate to crankshaft retaining bolts (1) and tighten to **30 N·m (22 lb ft)**.

   Tighten the bolts an additional 45 degrees using the *J 45059* meter .

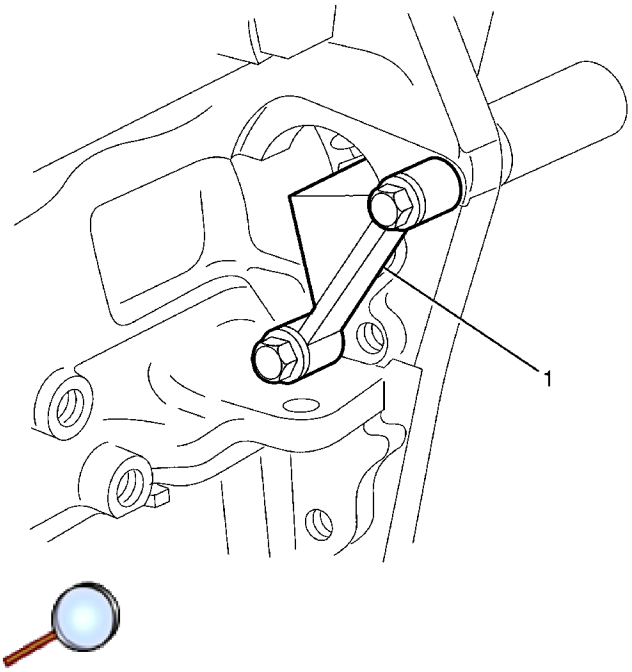
Crankshaft Balancer Installation

Installation - Up to xx/xx

Special Tools

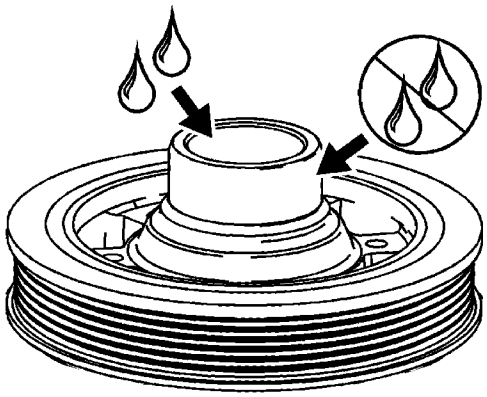
- *EN 46106* Engine Flywheel Holding Tool
- *J 41998-B* Crankshaft Balancer Installer
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.



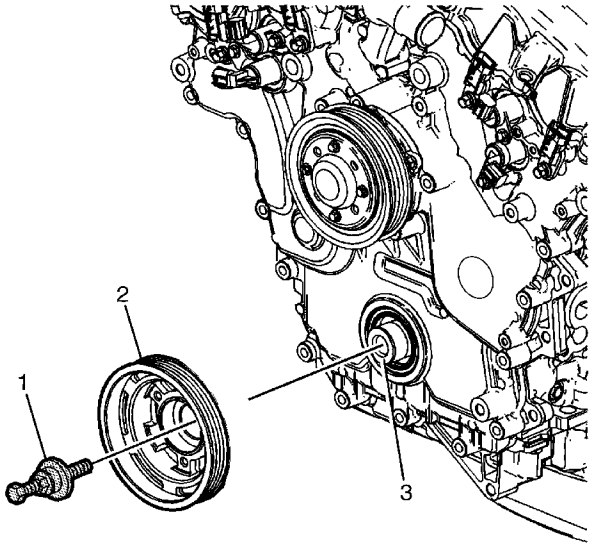
1. The *EN 46106* tool (1) must be installed.

© 2010 General Motors Corporation. All rights reserved.



Note: DO NOT lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

2. Apply lubricant to the inside of the crankshaft balancer hub bore.

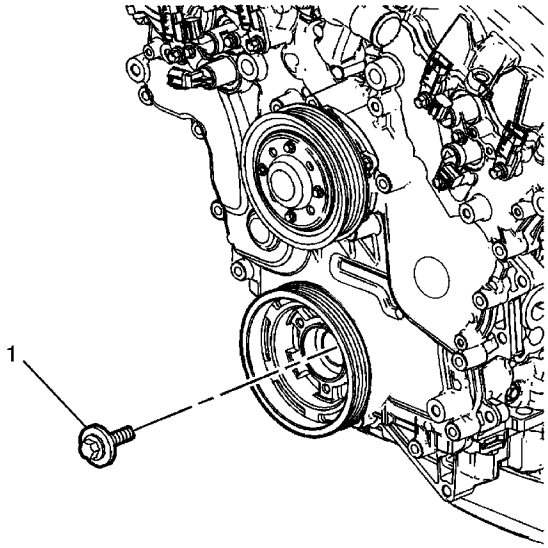


Note: Use the *J 41998-B* installer (1), nut, bearing and washer to install the crankshaft balancer (2).

Note: Make sure at least 10 threads of the *J 41998-B* installer (1) are engaged before pressing the crankshaft balancer (2) in place.

3. Thread the *J 41998-B* installer (1) in the crankshaft (3).

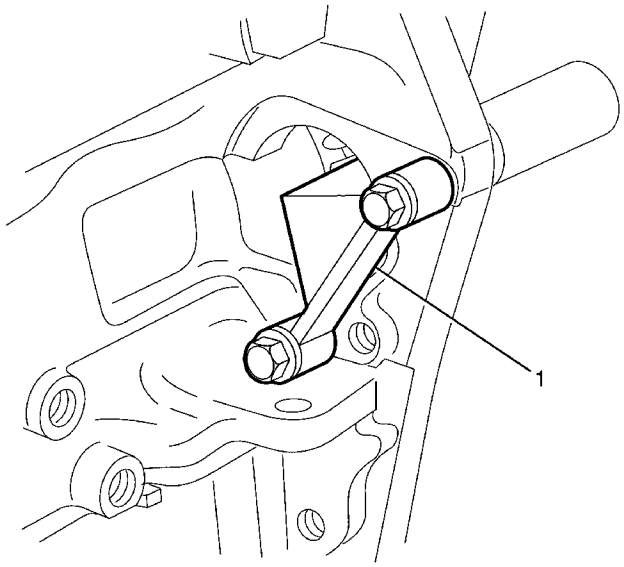
4. Push the crankshaft balancer (2) into position by tightening the nut on the *J 41998-B* installer (1) until the large washer bottoms out on the crankshaft (3) end.
5. Remove the *J 41998-B* installer (1).



6. Install the crankshaft balancer to crankshaft retaining bolt (1).

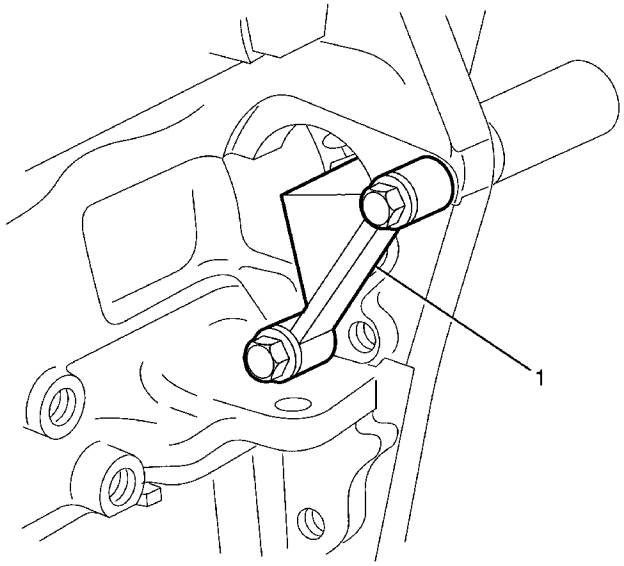
Caution: Refer to Fastener Caution in the Preface section.

7. Tighten the crankshaft balancer to crankshaft retaining bolt.
   - Tighten the bolt to **100 N·m (74 lb ft)**.
   - Tighten the crankshaft balancer to crankshaft retaining bolt an additional 150 degrees using the *J 45059* meter .

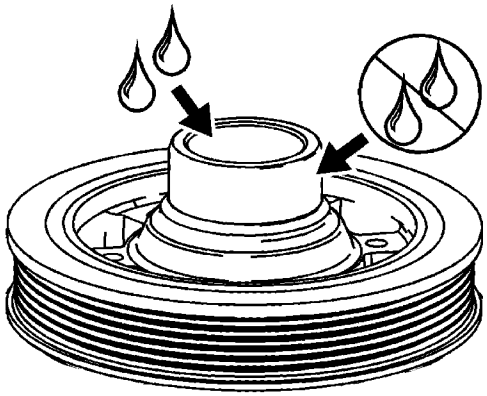


8. Remove the *EN 46106* tool (1).

Installation After - xx/xx

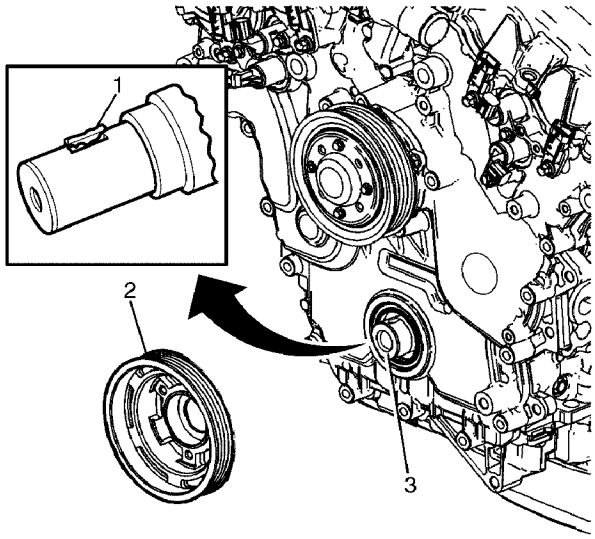


1. The *EN 46106* tool (1) must be installed.



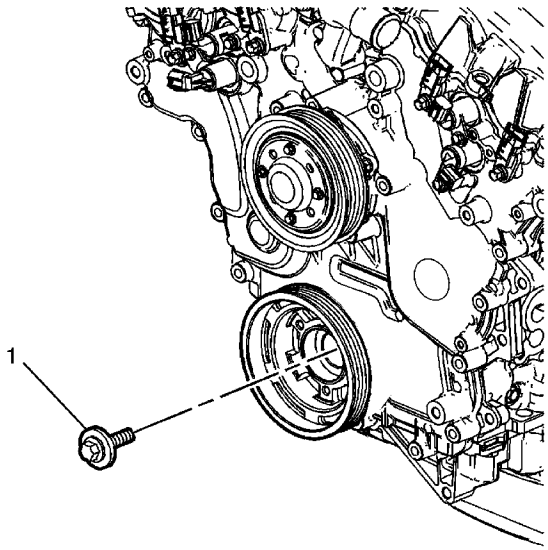
Note: DO NOT lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

2. Apply lubricant to the inside of the crankshaft balancer hub bore.

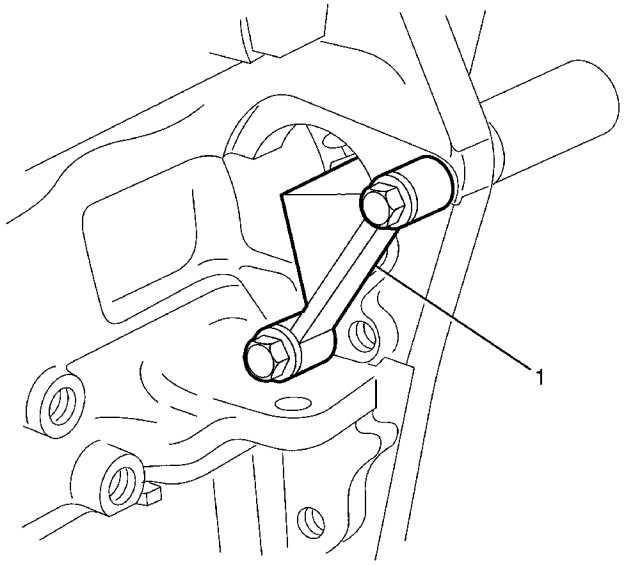


Note: Make sure the key (1) located on the top of the crankshaft is correctly installed in the crankshaft. Failure to adhere to this may cause engine damage.

3. Install the crankshaft balancer (2) on to the crankshaft (3).

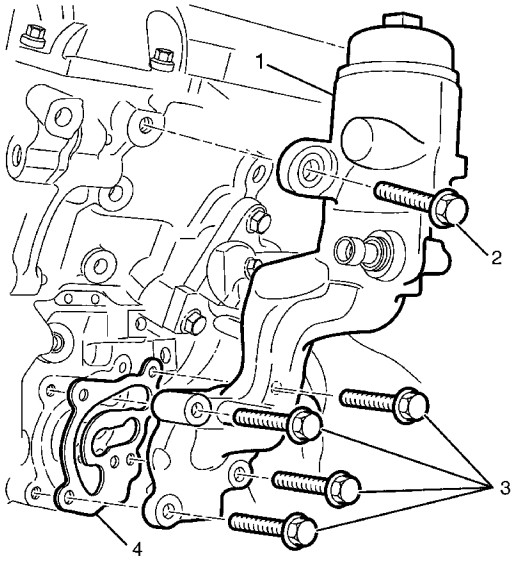


4. Install the crankshaft balancer to crankshaft retaining bolt (1).
   - Tighten the bolt to **100 N·m (74 lb ft)**.
   - Tighten the crankshaft balancer to crankshaft retaining bolt an additional 150 degrees using the *J 45059* meter .



5. Remove the *EN 46106* tool (1).

Oil Filter Adapter Installation

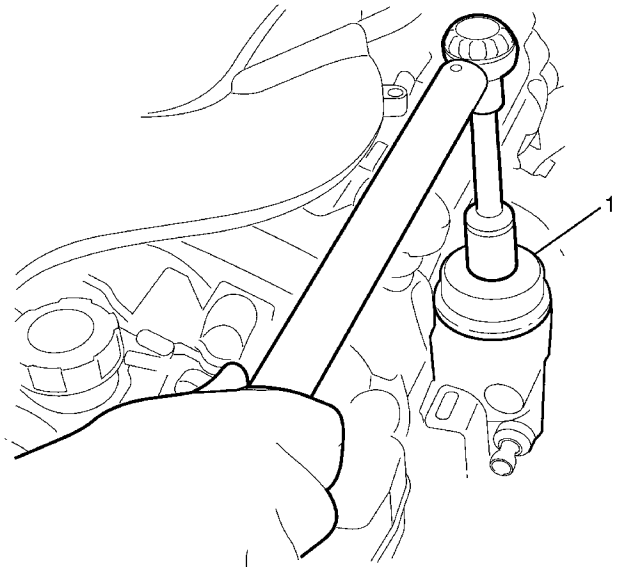


1. Position a NEW oil filter adapter gasket (4) onto the oil filter adapter (1).
2. Install the M8 lower oil filter adapter to cylinder block retaining bolts (3).
3. Loosely tighten the M8 lower oil filter adapter to cylinder block retaining bolts (3).
4. Install the M10 upper oil filter adapter to cylinder head retaining bolt (2).
5. Loosely tighten the M10 upper oil filter adapter to cylinder head retaining bolt (2).

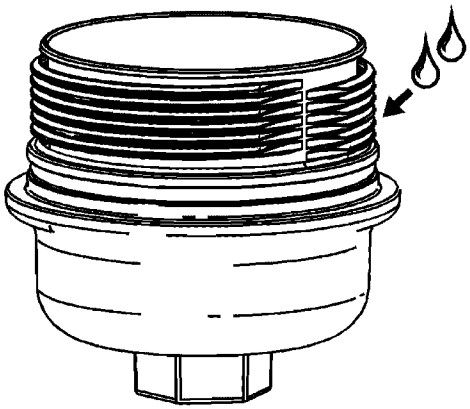
Caution: Refer to Fastener Caution in the Preface section.

6. Tighten the M8 lower oil filter adapter to cylinder block retaining bolts (3) and tighten to **23 N·m (17 lb ft)**.
7. Tighten the M10 upper oil filter adapter to cylinder head retaining bolt (2) and tighten to **58 N·m (42 lb ft)**.

© 2010 General Motors Corporation. All rights reserved.

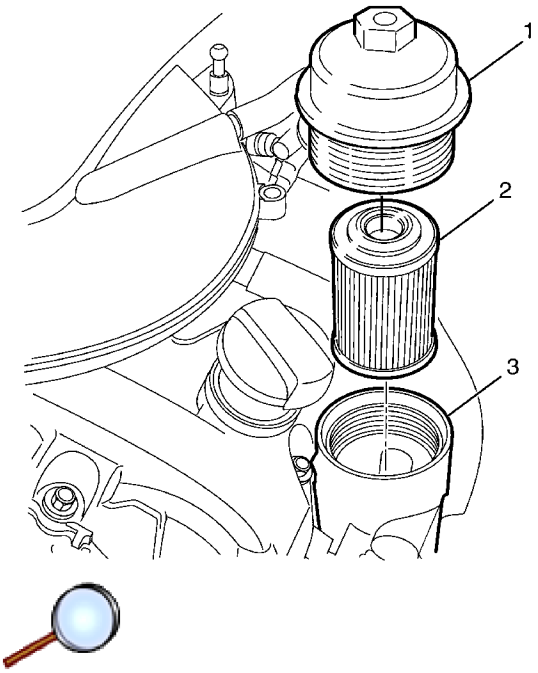


8. Remove the oil filter cap (1).



Caution: Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

9. Lubricate the oil filter cap threads with clean engine oil.



10. Install the NEW oil filter cartridge (2).

Caution: Proper oil filter cap tightening is mandatory. Failure to tighten the oil filter cap to the proper specification can hinder later removal and cause possible oil filter cap damage.

Note: Use a six-point socket to install the oil filter cap.

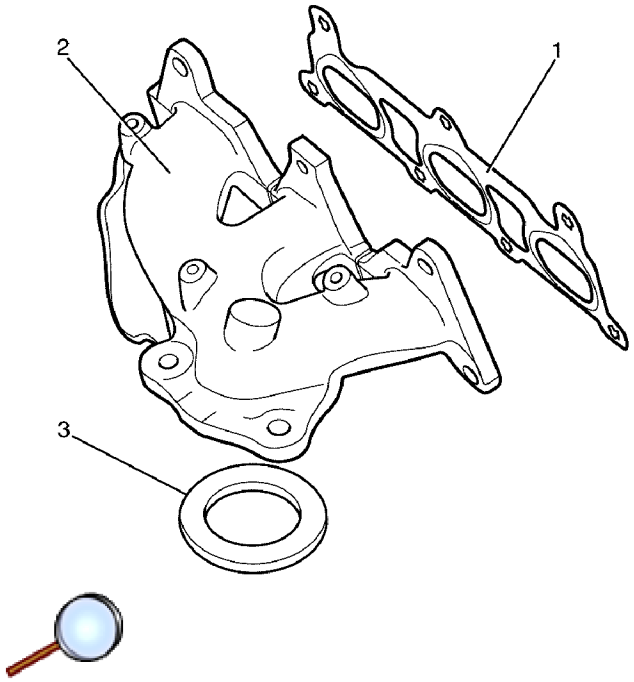
11. Install the oil filter adapter cap (1) to the engine oil filter adapter (3) and tighten to **25 N·m (18 lb ft)**.

Exhaust Manifold Installation - Left Side

Installation Procedure

Caution: Refer to Exhaust System Inspection Caution in the Preface section.

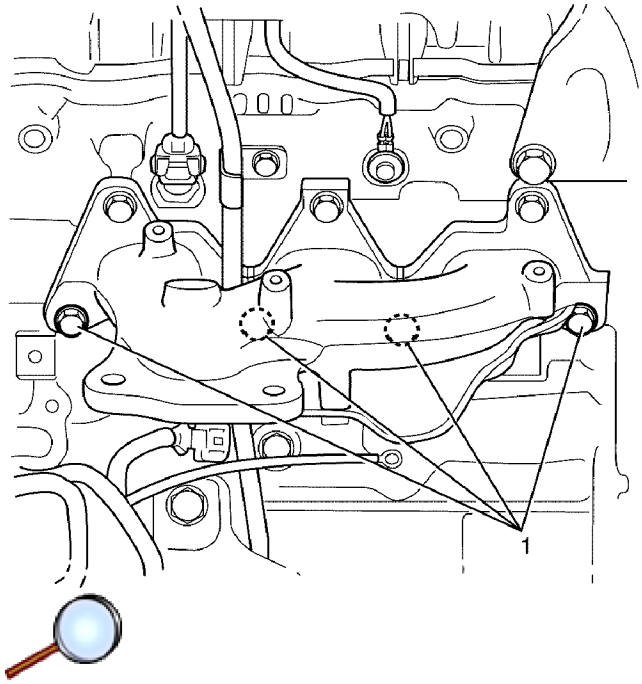
1. Inspect the exhaust manifold before installation. Refer to Exhaust Manifold Cleaning and Inspection - Left Side .



Note: Make sure the sealing ring is seated correctly.

2. Install a NEW exhaust manifold gasket (1) and NEW sealing ring (3) to the exhaust manifold (2).
3. Install the exhaust manifold assembly (2) to the engine.

© 2010 General Motors Corporation. All rights reserved.

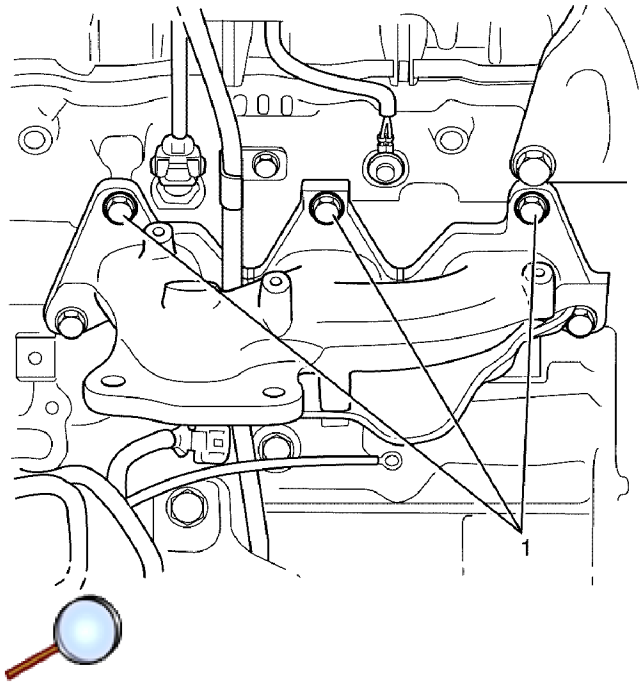


Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

4. Install NEW exhaust manifold to cylinder head retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.

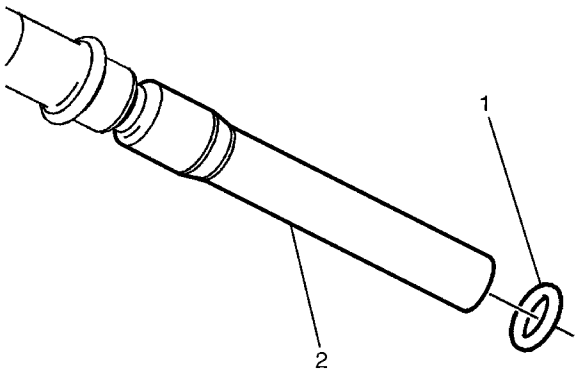
5. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N·m (15 lb ft)**.



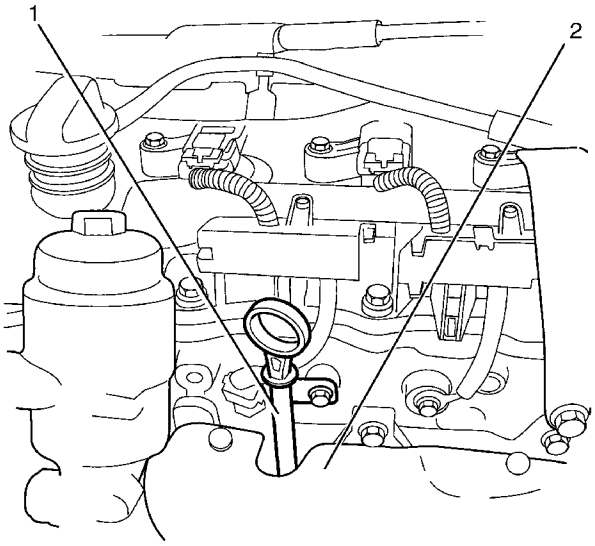
Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

6. Install NEW exhaust manifold to cylinder head retaining bolts (1).
7. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N·m (15 lb ft)**.

Oil Level Indicator and Tube Installation



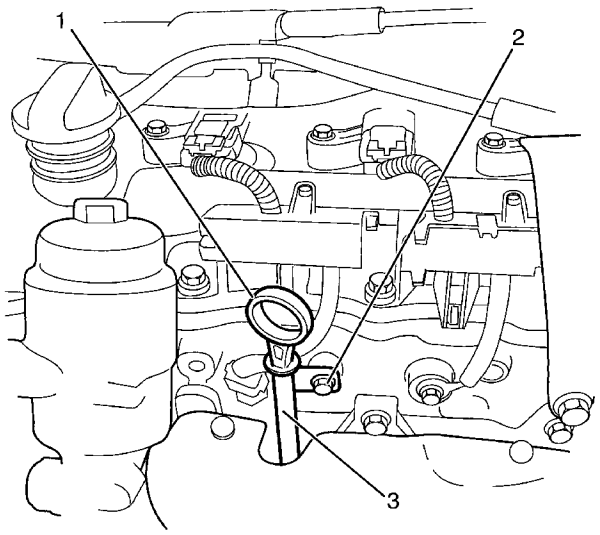
1. Install a NEW O-ring (2) on the oil level indicator tube (1).



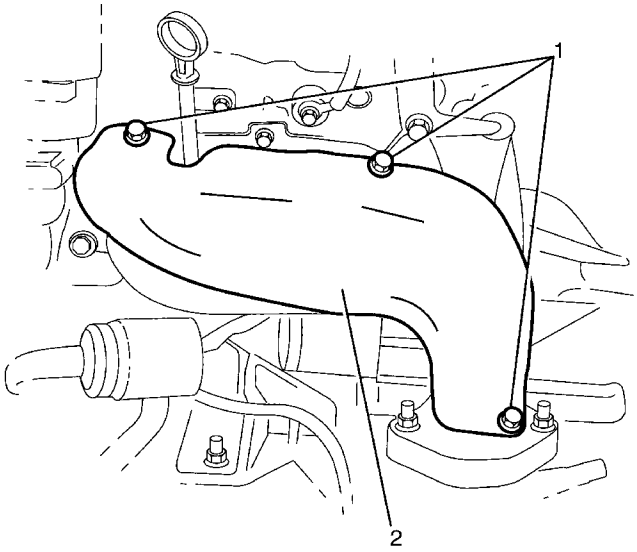
2. Install the oil level indicator and tube (1) by sliding the oil level indicator and tube (1) down through the exhaust manifold (2).

Caution: Refer to Fastener Caution in the Preface section.

© 2010 General Motors Corporation. All rights reserved.



3. Install the oil level indicator tube bracket to cylinder head retaining bolt (2) and tighten to **10 N·m (89 lb in)**.



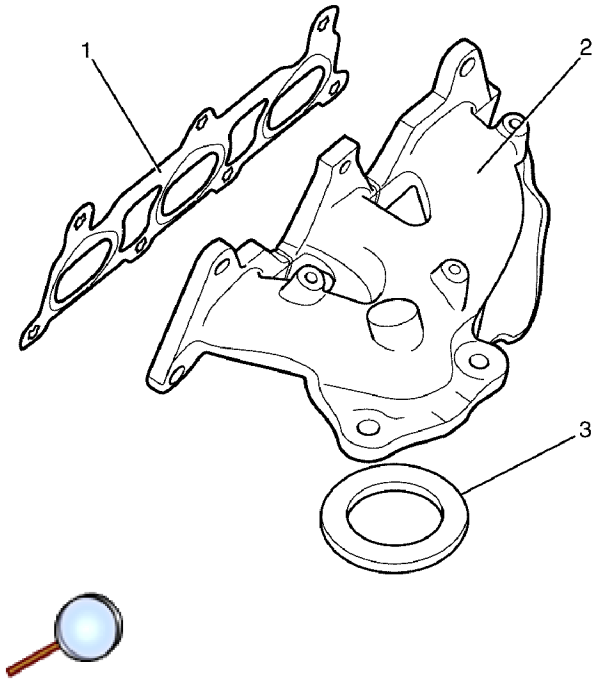
4. Install the exhaust manifold heat shield (2).
5. Install the exhaust manifold heat shield to exhaust manifold retaining bolts (1) and tighten to **10 N·m (89 lb in)**.

Exhaust Manifold Installation - Right Side

Installation Procedure

Caution: Refer to Exhaust System Inspection Caution in the Preface section.

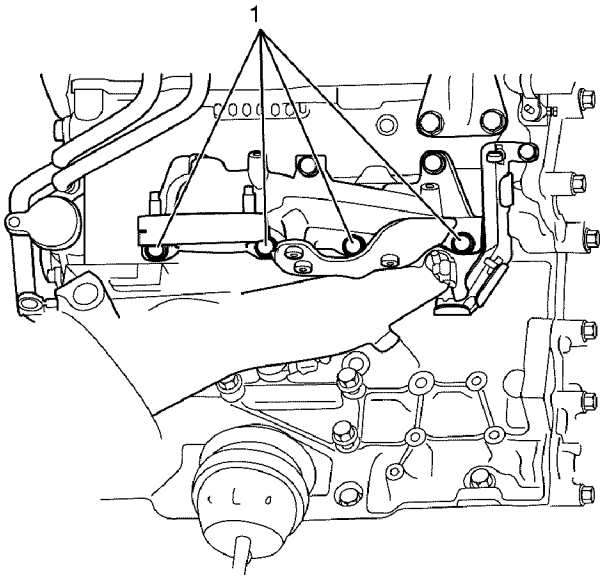
1. Inspect the exhaust manifold before installation. Refer to Exhaust Manifold Cleaning and Inspection - Right Side.



Note: Make sure the sealing ring is seated correctly.

2. Install a NEW exhaust manifold gasket (1) and NEW sealing ring (3) to the exhaust manifold (2).
3. Install the exhaust manifold assembly (2) to the engine.

© 2010 General Motors Corporation. All rights reserved.

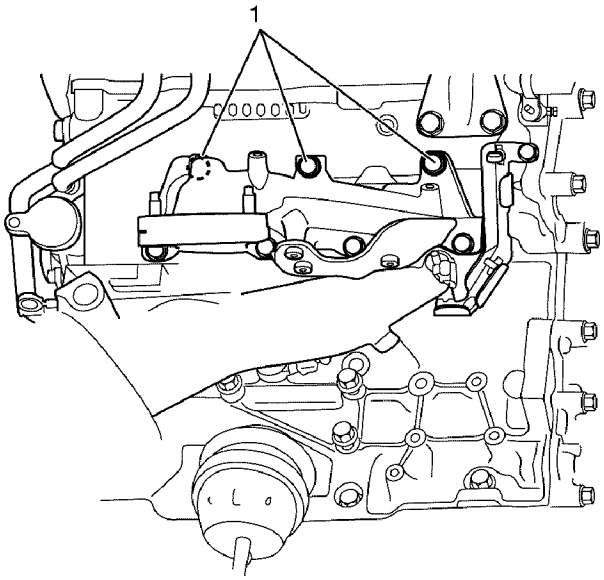


Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

4. Install NEW exhaust manifold to cylinder head retaining bolts (1).

Caution: Refer to Fastener Caution in the Preface section.

5. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N·m (15 lb ft)**.

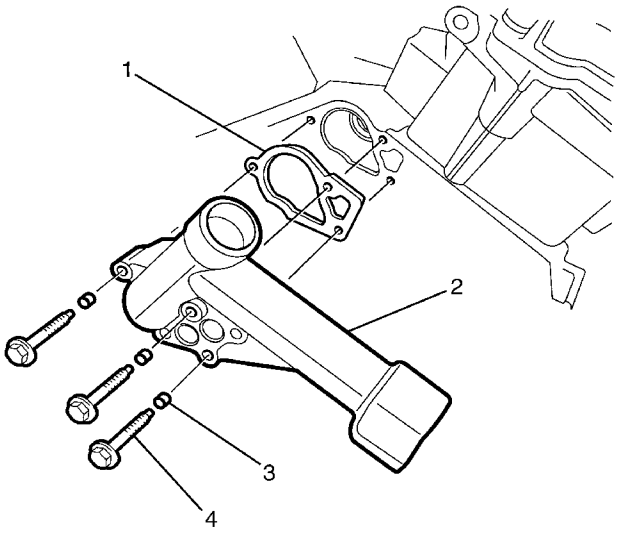


Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

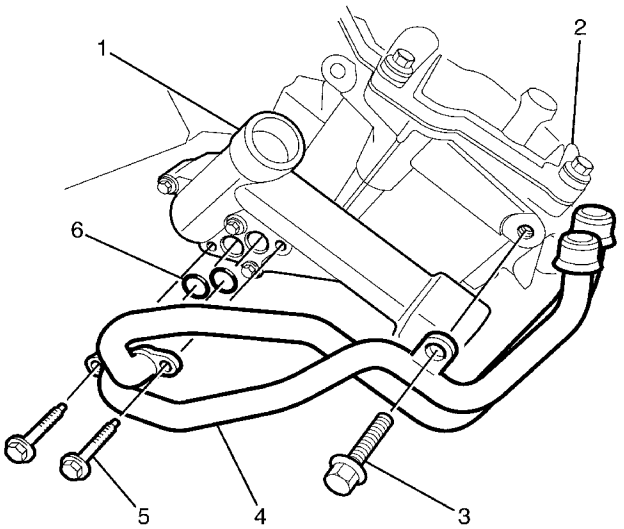
6. Install NEW exhaust manifold to cylinder head retaining bolts (1).
7. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N·m (15 lb ft)**.

Engine Coolant Thermostat Housing Installation

Caution: Refer to Fastener Caution in the Preface section.



1. Install thermostat housing to cylinder block retaining bolts (4) ensuring a new block gasket (1) and rubber grommets (3) has been fitted and tighten bolts to **10 N·m (89 lb in)**.

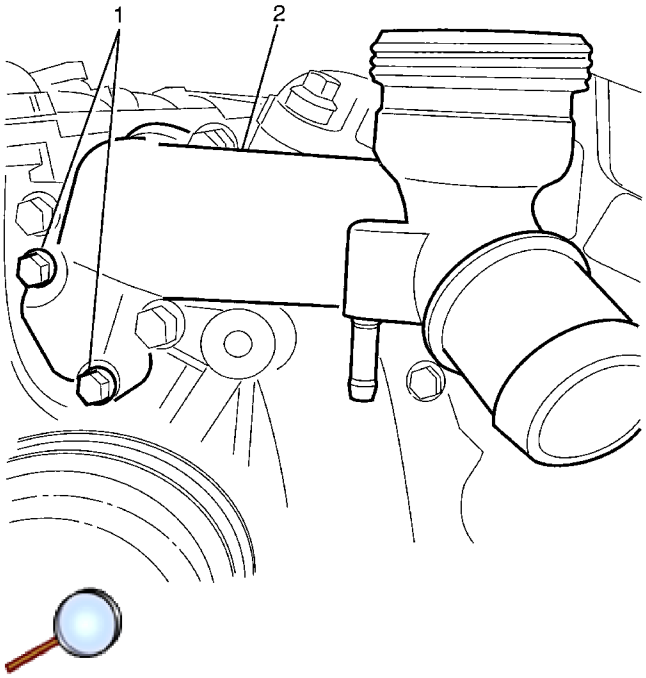


2. Install the heater pipe assembly to thermostat housing retaining bolts (5) ensuring new O-ring seals (6) have been fitted and tighten bolts to **10 N·m (89 lb in)**.

© 2010 General Motors Corporation. All rights reserved.

3. Install the heater pipe assembly (4) to cylinder head (2) retaining bolt (3) and tighten to **35 N·m (26 lb ft)**.

Water Outlet Installation



Note: Ensure a new rubber O-ring and seal is used when installing the water outlet housing.

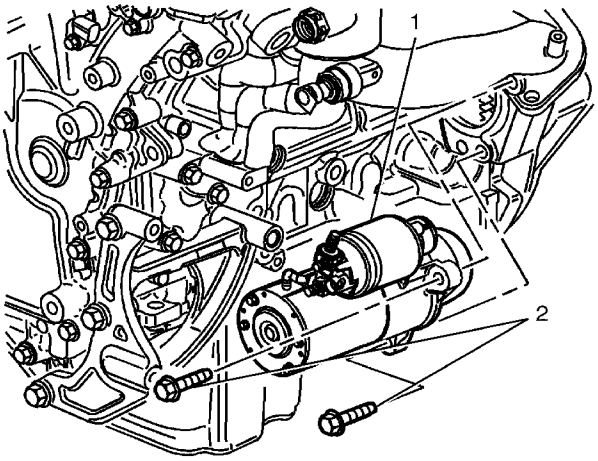
1. Install the coolant outlet housing (2) to the intake manifold.

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the coolant outlet housing to intake manifold retaining bolts (1) and tighten to **10 N·m (89 lb in)**.

© 2010 General Motors Corporation. All rights reserved.

Starter Installation



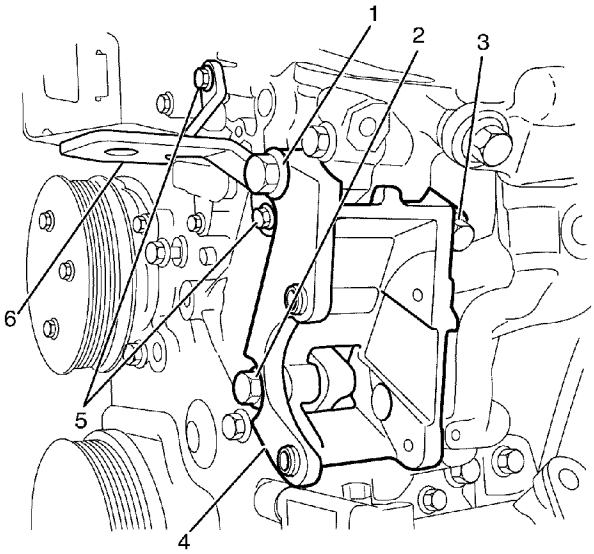
1. Install the starter motor (1).

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the starter motor to cylinder block retaining bolts (2) and tighten to **58 N·m (42 lb ft)**.

© 2010 General Motors Corporation. All rights reserved.

Power Steering Pump Installation



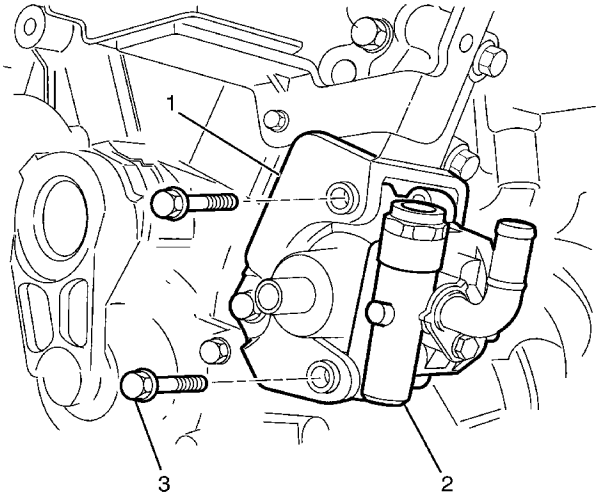
1. Install the power steering pump bracket (2).
2. Install the NEW power steering bracket to cylinder head retaining bolts (1).

   Tighten
   Tighten the bolts to 58 N·m (43 lb ft).

3. Install the power steering fluid reservoir bracket (4).
4. Install the NEW power steering fluid reservoir bracket to engine front cover retaining bolts (3).

   Tighten
   Tighten the bolts to 9 N·m (80 lb ft).

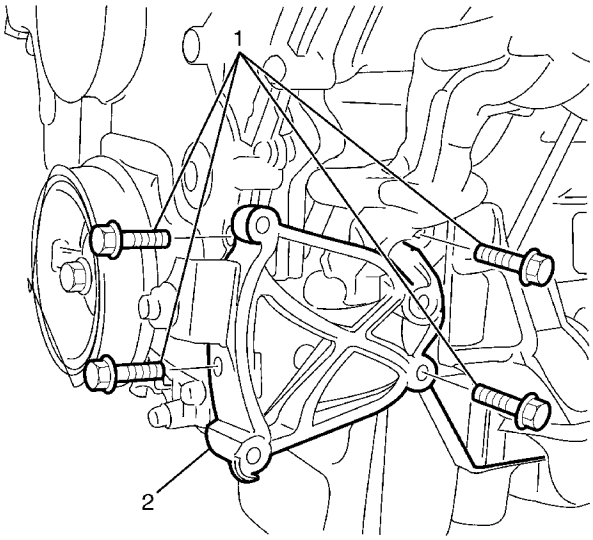
© 2010 General Motors Corporation. All rights reserved.



5. Install the power steering pump (2) to the power steering pump mounting bracket (3).
6. Install the power steering pump to mounting bracket retaining bolts (1).

Air Conditioning (A/C) Compressor Installation

Note: Follow the procedure sequence in order to prevent drive belt mis-alignment and/or possible damage/distortion to the components.

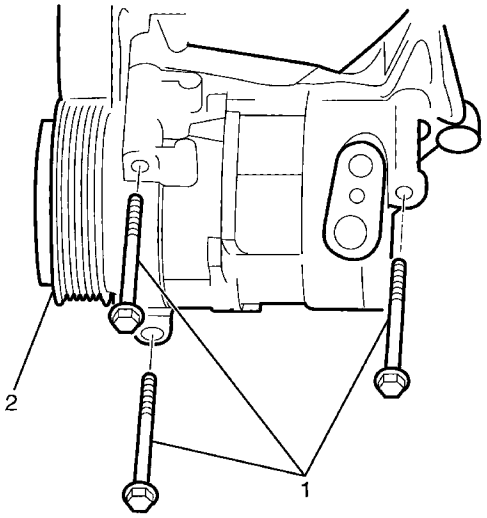


1. Install the A/C compressor bracket (2).

   Caution: Refer to Fastener Caution in the Preface section.

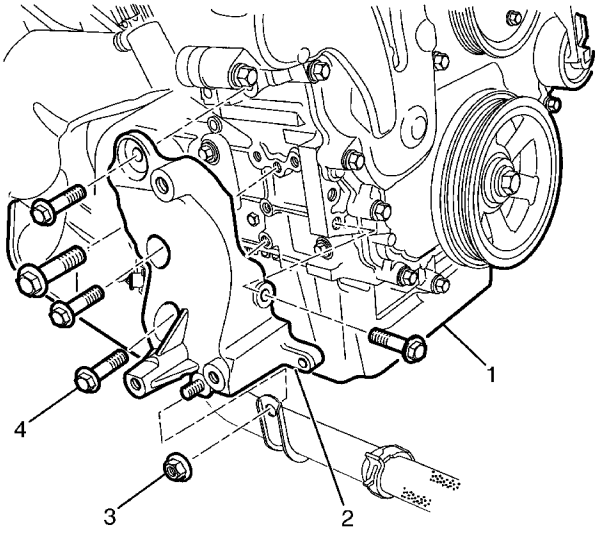
2. Install the A/C compressor bracket to cylinder block retaining bolts (1) and tighten to **58 N·m (42 lb ft)**.
3. If you are replacing the compressor, balance the compressor oil. Refer to Air Conditioning Compressor Oil Balancing.

© 2010 General Motors Corporation. All rights reserved.



4. Install the A/C compressor (2).
5. Install the A/C compressor to A/C compressor bracket retaining bolts (1) and tighten to **22 N·m (16 lb ft)**.

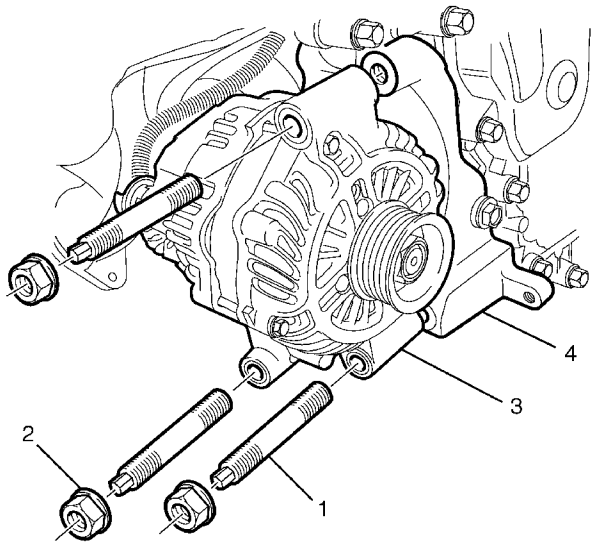
Generator Installation



1. Install the alternator bracket (2) to the engine block.

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the alternator bracket to engine block retaining bolts and tighten to **50 N·m (37 lb ft)**.
3. Install the coolant inlet pipe to alternator mounting bracket retaining nut (3) and tighten to **22 N·m (16 lb ft)**.



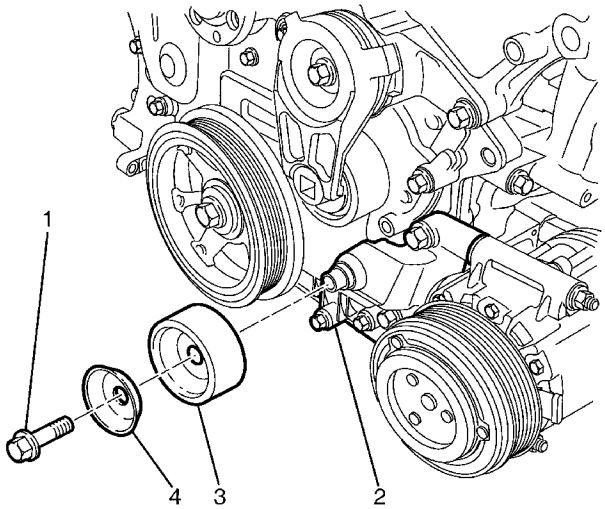
© 2010 General Motors Corporation. All rights reserved.

4. Position the alternator (3) on the alternator mounting bracket (4).

   Note: The alternator mounting studs (4) have hexagonal outer ends to assist with removal and installation.

5. Install the alternator to alternator bracket retaining studs (1) if required and tighten to **18 N·m (13 lb ft)**.
6. Install the alternator to alternator bracket stud retaining nuts (2) and tighten to **18 N·m (13 lb ft)**.

Drive Belt Idler Pulley Installation



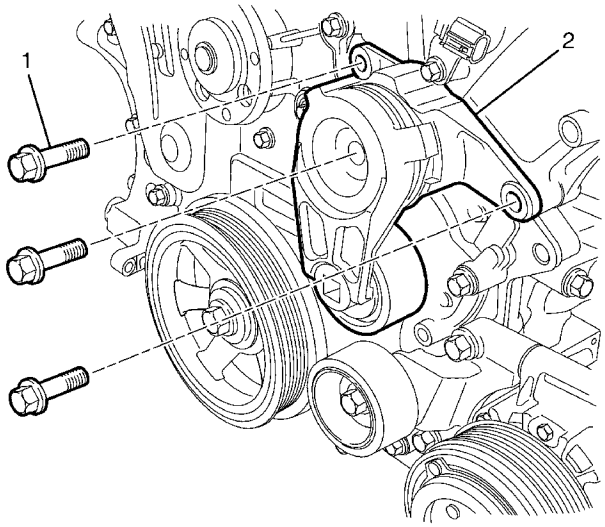
1. Install the dished washer (4) and drive belt idler pulley (3) to the accessory drive mounting bracket (2).
2. Hand tighten the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1).

   Caution: Refer to Fastener Caution in the Preface section.

3. Tighten the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1) and tighten to **22 N·m (16 lb ft)**.

© 2010 General Motors Corporation. All rights reserved.

Drive Belt Tensioner Installation



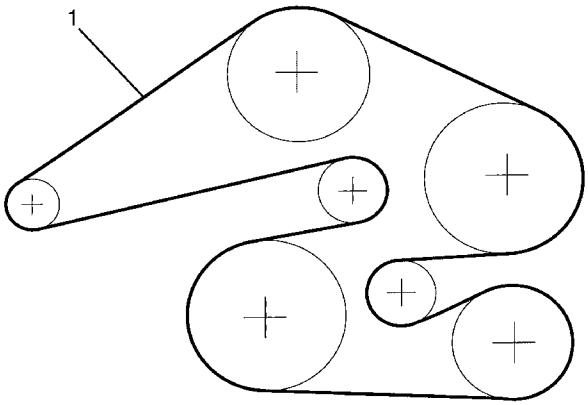
1. Install the drive belt tensioner (2) to the engine front cover.

   Caution: Refer to Fastener Caution in the Preface section.

2. Install the drive belt tensioner to engine front cover retaining bolts (1) and tighten to **22 N·m (16 lb ft)**.

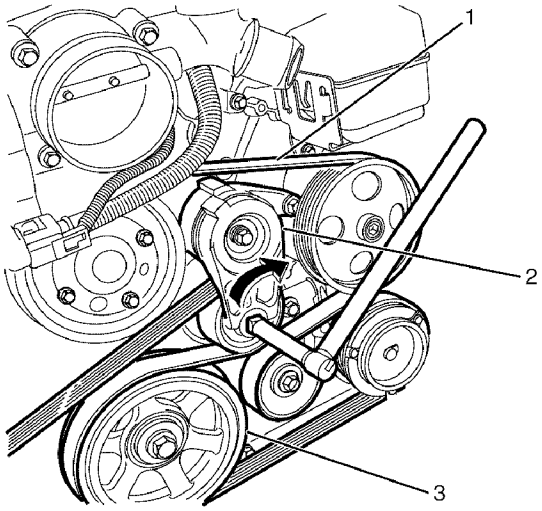
© 2010 General Motors Corporation. All rights reserved.

Drive Belt Installation



1. Install and correctly route the drive belt (1) around the following:
   - Water pump pulley
   - Generator
   - Drive belt tensioner
   - Crankshaft balancer
   - Air conditioning compressor
   - Idler pulley
   - Power steering pump

© 2010 General Motors Corporation. All rights reserved.

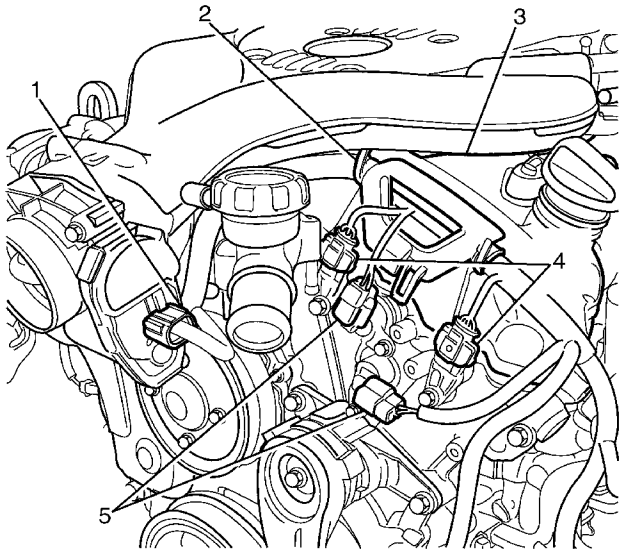


2. Using a suitable tool rotate the drive belt tensioner (2) clockwise.
3. Install the drive belt (1) to the crankshaft pulley (3).

Important: Make sure the drive belt (1) is correctly aligned and seated into the grooves of the accessory drive pulleys.

4. Slowly release the drive belt tensioner (2).
5. Remove the suitable tool from the drive belt tensioner (2).

Engine Wiring Harness Assembly Installation



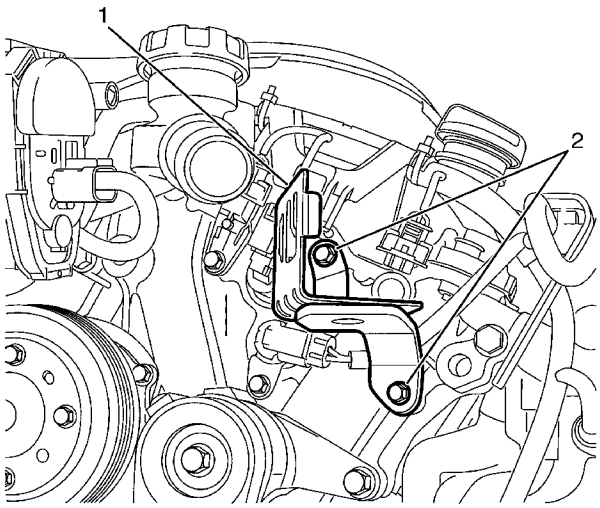
Important: Attach the engine wiring harness bracket (2) to the locating clip lug on the left bank camshaft cover (3) to avoid an induced rattle condition.

1. Attach the engine wiring harness bracket (2) to the left bank camshaft cover (3).
2. Connect the throttle position sensor electrical connector (1).

Important: LE0 and LW2 engines only have intake camshaft position actuator solenoids.

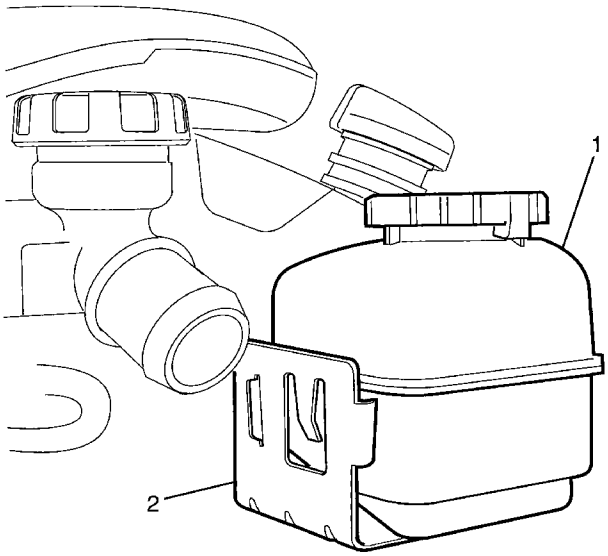
3. Connect the left bank intake and exhaust camshaft position actuator solenoid electrical connectors (5).
4. Connect the left camshaft position sensors electrical connectors (4).

© 2010 General Motors Corporation. All rights reserved.



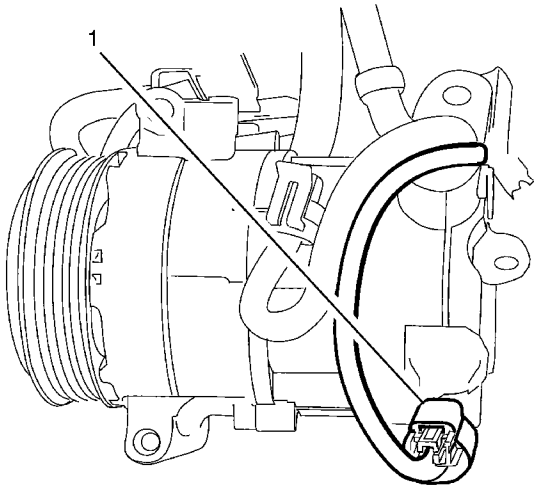
5. Install the power steering fluid reservoir bracket (1).
6. Install the power steering fluid reservoir bracket to engine front cover retaining bolts (2).

Tighten
Tighten the bolts to 9 N·m (80 lb in).

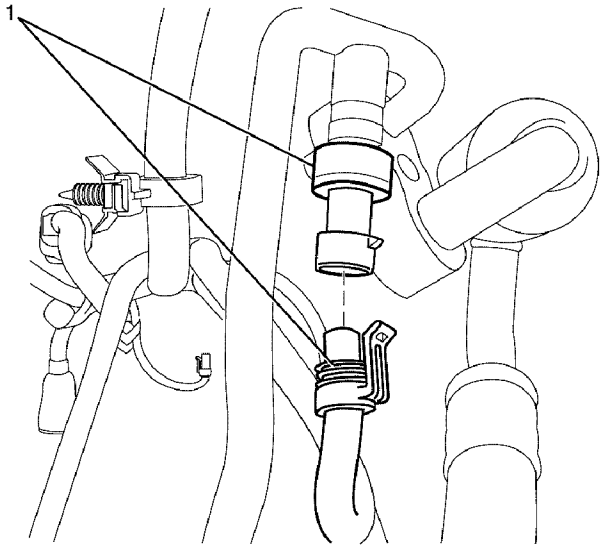


Important: Make sure the power steering reservoir (1) and the the locking tang on the power steering reservoir bracket (2) are engaged to avoid an induced rattle condition.

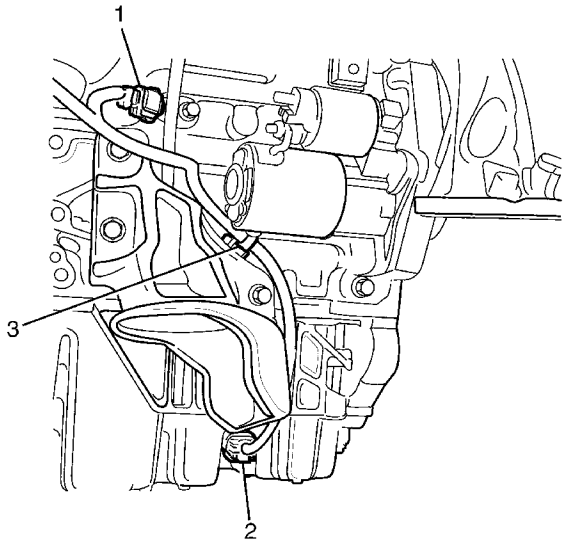
7. Install the power steering fluid reservoir to the power steering fluid reservoir bracket.



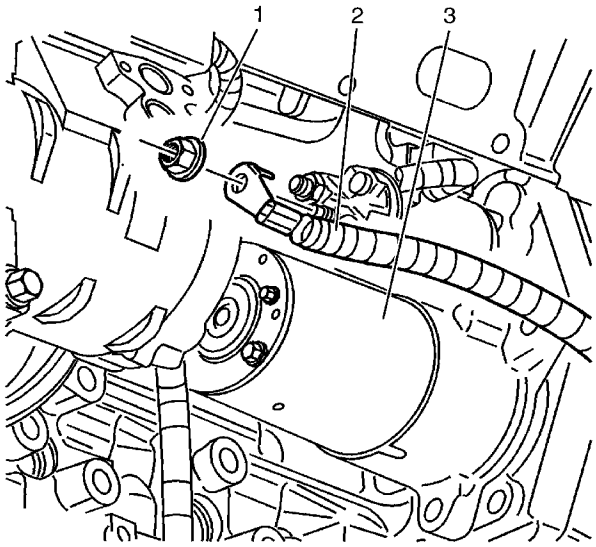
8. Connect the A/C compressor electrical connector (1).



9. Connect the A/C pressure transducer electrical connector (1).



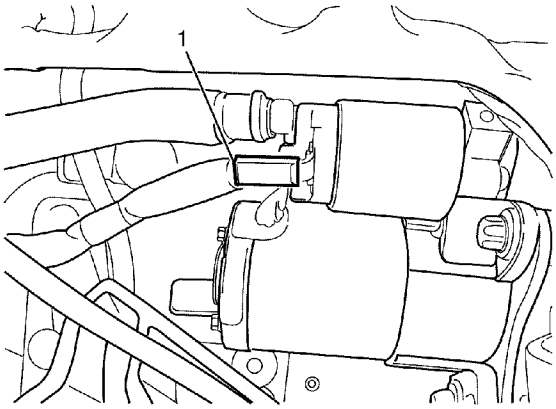
10. Attach the engine wiring harness to cylinder block retaining lug (3).
11. Connect the oil level sensor electrical connector (2).
12. Connect the left bank knock sensor electrical connector (1).



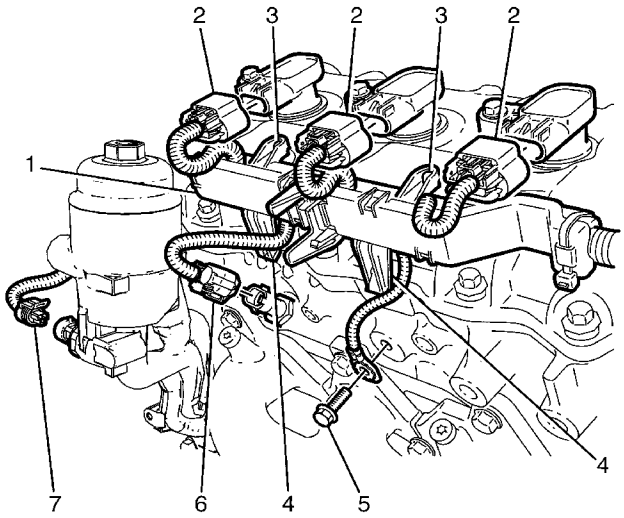
13. Install the battery positive cable to starter motor terminal retaining nut (1).

Tighten
Tighten the nut to 20 N·m (14 lb ft).

14. Connect the battery positive cable (2) to the starter motor (3).



15. Connect the starter motor electrical connector (1).

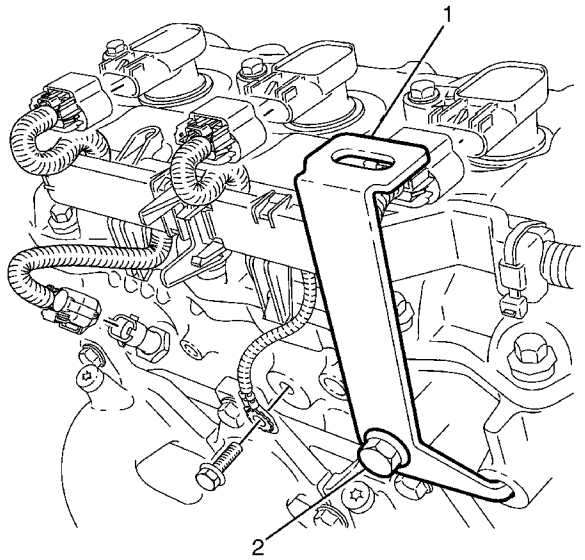


Important: Attach the engine wiring harness (1) clips to the right bank camshaft cover clips (4) and lugs (3) to avoid an induced rattle condition.

16. Attach the engine wiring harness bracket (1) to the right bank camshaft cover lugs (3).
17. Connect the oil pressure sensor electrical connector (7).
18. Connect the coolant temperature sensor electrical connector (6).
19. Install the engine wiring harness ground and engine wiring harness ground to left bank cylinder head retaining bolt (5).

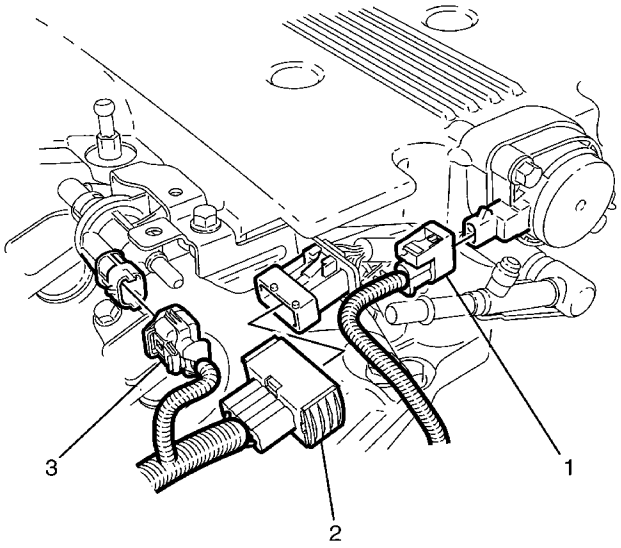
Tighten
Tighten the bolt to 10 N·m (89 lb in).

20. Connect the left bank ignition coil electrical connectors (2).

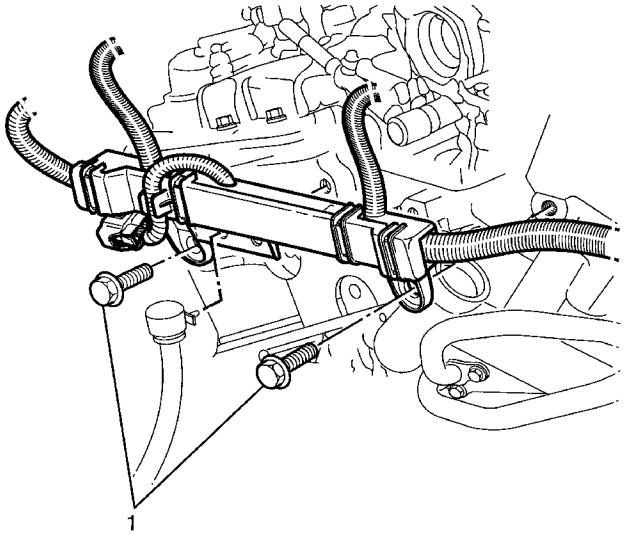


21. Install the engine cover bracket (1).
22. Install the engine cover bracket to cylinder head retaining bolt (2).

Tighten
Tighten the bolt to 35 N·m (26 lb ft).

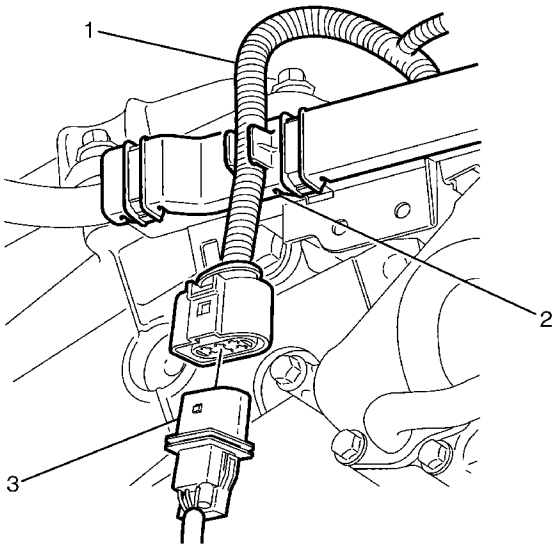


23. Connect the purge solenoid electrical connector (3).
24. Connect the injector harness electrical connector (2).
25. Connect the Intake Manifold Runner Control (IMRC) electrical connector (1).

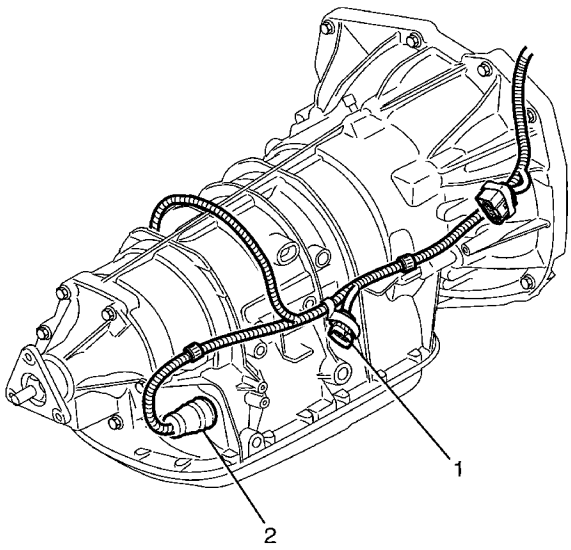


26. Install the engine wiring harness bracket to cylinder head retaining bolts (1).

Tighten
Tighten the nut to 40 N·m (30 lb ft).

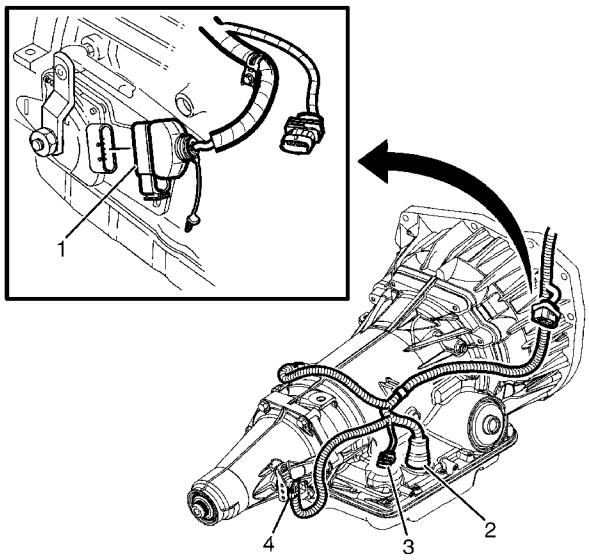


27. Attach the left hand Heated Oxygen Sensor 1 electrical harness (1) to the engine wiring harness bracket (2).
28. Connect the left hand Heated Oxygen Sensor 1 electrical connector (3).



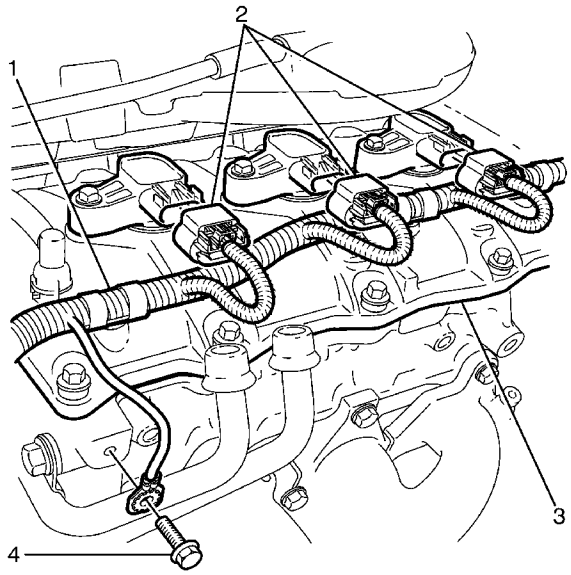
Important: Steps 30 and 31 refer to the 5L40E 5 speed automatic transmission only.

29. Connect the right hand Heated Oxygen Sensor 1 electrical connector (1).
30. Connect the main transmission electrical connector (2).



Important: Steps 33-36 refer to the 4L60E 4 speed automatic transmission only.

31. Connect the right hand Heated Oxygen Sensor 1 electrical connector (2).
32. Connect the main transmission electrical connector (3).
33. Connect the vehicle speed sensor electrical connector (4)
34. Connect the park/neutral switch electrical connector (1).

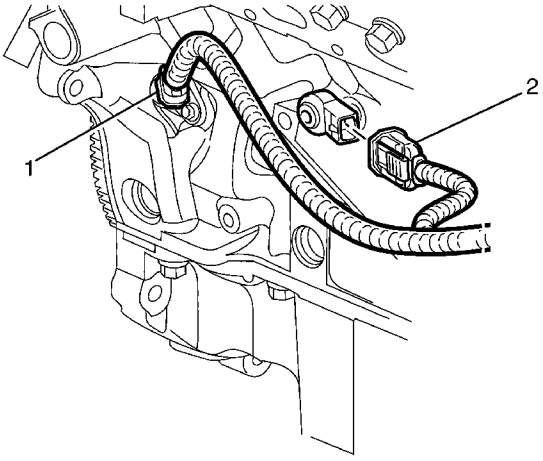


Important: Attach the engine wiring harness (1) clips to the right bank camshaft cover (4) to avoid an induced rattle condition.

35. Attach the engine wiring harness (1) to the right bank camshaft cover (3).
36. Install the engine wiring harness ground and engine wiring harness ground to right bank cylinder head retaining bolt (4).

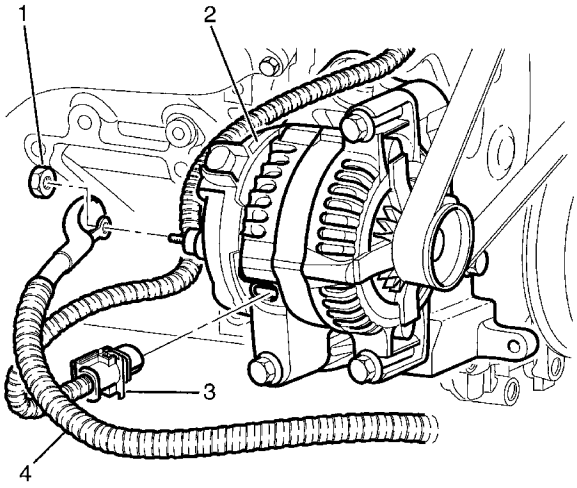
Tighten
Tighten the bolt to 10 N·m (89 lb in).

37. Connect the right bank ignition coil electrical connectors (2).



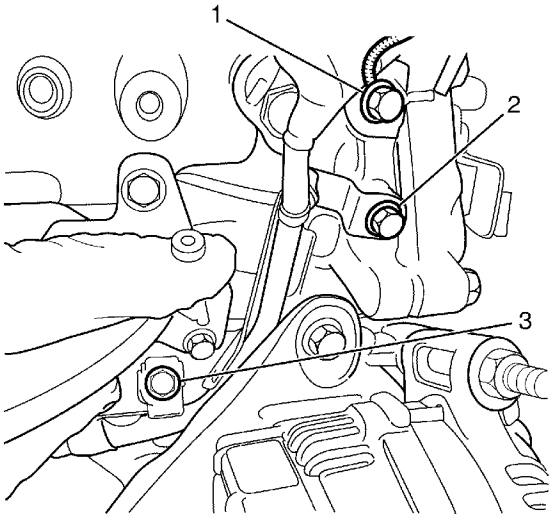
38. Connect the crankshaft position sensor electrical connector (1).

39. Connect the right bank knock sensor electrical connector (2).
40. Install the alternator and mounting bracket. Refer to Generator Installation.



41. Connect the alternator battery harness connector (3).
42. Connect the battery positive cable (4) from the alternator (2).
43. Install the battery positive cable to alternator retaining nut (1).

Tighten
Tighten the nut to 13 N·m (115 lb in).



44. Install the engine wiring harness bracket to cylinder block retaining bolt (3).

Tighten

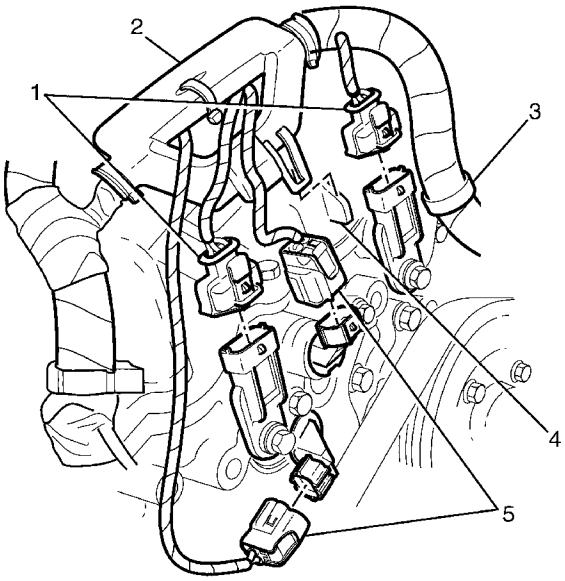
Tighten the nut to 10 N·m (89 lb in).

45. Install the engine wiring harness bracket to right bank cylinder head retaining bolt (2).

Tighten
Tighten the nut to 10 N·m (89 lb in).

46. Install the engine wiring harness ground to right bank cylinder head retaining bolt (1).

Tighten
Tighten the nut to 10 N·m (89 lb in).



Important: Attach the engine wiring harness bracket (2) to the locating clip lug on the right bank camshaft cover (4) to avoid an induced rattle condition.

47. Attach the engine wiring harness bracket (2) from the right bank camshaft cover (4).
48. Attach the engine wiring harness to cylinder head retaining lug (3).

Important: LE0 and LW2 engines only have intake camshaft position actuator solenoids.

49. Connect the right bank intake and exhaust camshaft position actuator solenoid electrical connectors (5).
50. Connect the right camshaft position sensors electrical connectors (1).
51. Install the engine covers. Refer to Engine Cover Replacement.

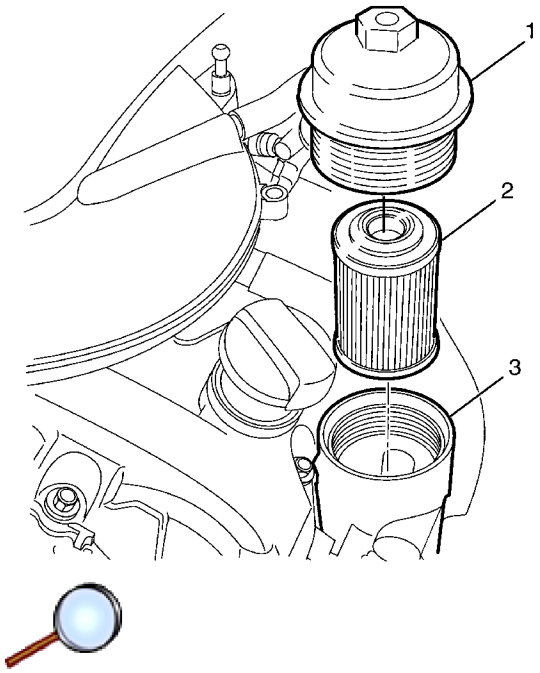
Engine Prelubing

Special Tools

J 45299 Engine Preluber

For equivalent regional tools, refer to Special Tools.

Note: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

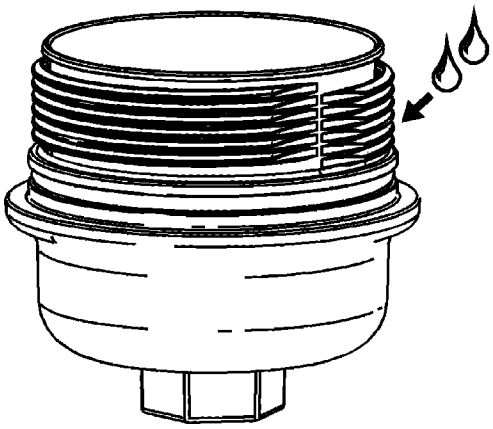


Note: Use a six-point socket to remove the oil filter cap (1).

1. Remove the oil filter adapter cap (1) from the engine oil filter adapter (3).
2. Remove the oil filter cartridge (2).

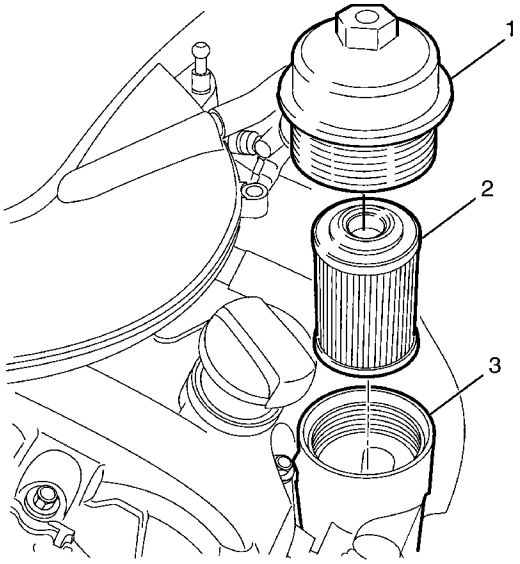
   Discard the oil filter cartridge (2).

© 2010 General Motors Corporation. All rights reserved.



Caution: Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

3. Lubricate the oil filter cap threads with clean engine oil.



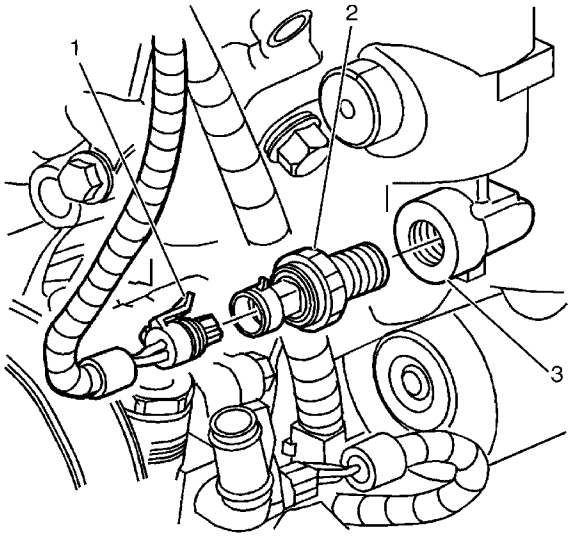
4. Install the NEW oil filter cartridge (2).

Caution: Refer to Fastener Caution in the Preface section.

Caution: Proper oil filter cap tightening is mandatory. Failure to tighten the oil filter cap to the proper specification can hinder later removal and cause possible oil filter cap damage.

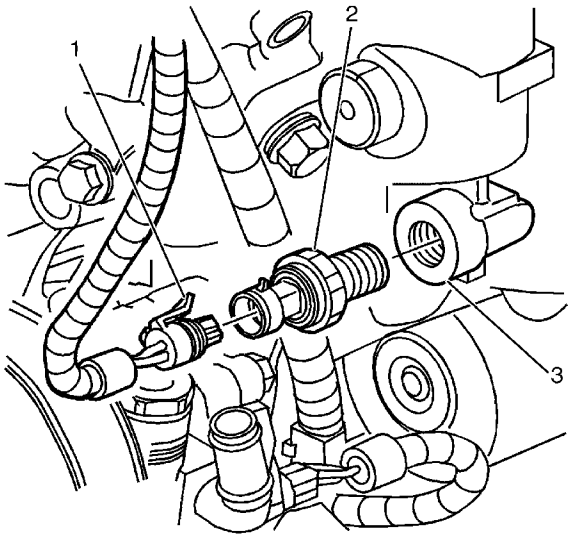
Note: Use a six-point socket to install the oil filter cap.

5. Install the oil filter adapter cap (1) to the engine oil filter adapter (3) and tighten the oil filter cap to **25 N·m (18 lb ft)**.



Note: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

6. Remove the oil pressure sending unit (2) from the oil filter adapter (3).
7. Disconnect the oil pressure sending unit electrical connector (1).
8. Install a 14 x 1.5 mm adapter to the oil filter adapter (3).
9. Install the flexible hose to the adapter and open the valve.
10. Pump the handle on the *J 45299* preluber in order to flow a minimum of 1-1.9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
11. Close the valve and remove the flexible hose and adapter from the oil filter adapter.



12. Install the oil pressure sending unit (2) to the oil filter adapter (3) and tighten the oil pressure sending unit to **20 N·m (15 lb ft)**.
13. Connect the oil pressure sending unit electrical connector (1).
14. Top-off the engine oil to the correct level.